POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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The Silver Lining in the Boiler Situation

WHATEVER ONE MAY SAY of the political situation, or the economic situation, or indeed any situation you may elect to consider, the boiler situation at least has a silver lining. Boiler salesmen, coal heavers and captains of industry may doubt this assertion and offer evidence in support of the contrary but that does not worry us, for we present evidence to prove our contention in the form of the photograph shown herewith.

"One swallow," however, according to an old saw, "does not make a summer," and we don't imply that a picture of a single boiler plant under construction is evidence of a "pick-up" in the boiler industry but, despite this, our silver lining statement stands. For we mean it literally—these curious looking boilers will have silver linings, that is, quicksilver linings, for they are mercury boilers.

Last month the 50th anniversary of the opening of Pearl St. station was commemorated in New York City. It is a far cry from the Jumbo dynamos of Pearl Street to this ultra modern mercury vapor and steam plant of the General Electric Co. now under construction at Schenectady and yet, in a certain sense there is a similarity between them. Pearl St. was the beginning of a new era in our civilization—the era of electricity; this new station, though it will not affect civilization as profoundly as did Pearl St., nevertheless incorporates radically new ideas, the future development of which may affect power station practice.

Mercury boilers! What an idea! Who can say what startling developments may arise from this? Just the other day in discussing this development with one of our imaginative editors, he painted for us a future in which mercury boilers would be made of pyrex glass and operated electrically so that they would serve both as boilers and mercury vapor lamps. And while we were speculating, we concluded that in addition to functioning as boilers and lamps they might also be made to serve as mercury arc rectifiers for converting the alternating current output of the plant into direct current for transmission purposes.

But to be serious, this plant has many unusual features as it is. Aside from the use of mercury vapor turbines, it will be the first outdoor steam electric generating plant in the world and represent the first instance of coordinating utility and industrial power needs. The electric output of the station will be delivered to the commercial system of the New York Power and Light Corporation while the steam output will be used in the Schenectady plant of the General Electric Co. It is a plant that looks far into the future. Costing $4,000,000 and having an output of 20,000 kw. and 325,000 lb. of steam per hr. at 400 lb. pressure, it is predicted that this plant will produce steam and electricity at a lower cost than ever before.

Buying Balloons

Speaking of costs and economy, wouldn't the balloon manufacturers like to sell balloons blown up? A half ounce of rubber when blown up makes a five cubic foot sphere and takes perhaps 25,000 times as much space as it does deflated. Nobody but a "dumbell" would buy balloons blown up on a volumetric basis. Yet many people who buy hogged fuel are doing just that—buying units without the least idea of how much heat they are getting for their money. In this issue, Mr. Beecher, who has had much experience in this field, presents some valuable pointers on avoiding this skin game. Better read it, not necessarily for your own good but to laugh at other people who pay good money for useless air and water.

Hi-lo-Jack

The pump man says keep them low and the compressor man says keep them high for best results. Both are talking about the same thing and both know their business. Of course, we realize that, as Mark Twain said, it is a difference of opinion that makes horse races, but what is a poor engineer to do when he comes to this matter of proper pump suction? A simple answer to what Chic Sales would say is a mighty important question is, call in a specialist. That's what we did and after you read Mr. Knoy's article on page 762 on the value of high suction pressure in ice plants you'll feel like a specialist yourself. But don't let your enthusiasm run away with you. Keep your pump suction low until we have a chance to tell you why in more detail in some other issue.

WITH THE EDITORS

Start for Progressive Modernization

BETTER SPIRIT, more optimism are evident in the talking and thinking of the "man on the street", be he manufacturer, worker or merchant. The problem is to translate this spirit into doing.

It can be made into a business-building circle—purchase of equipment, which will give employment to workers, who will receive wages to buy needed goods and supplies, which will call for more workers and for operation of more equipment—and so on. From a start, gradual accretion will lead up to normal business activity.

To get a start's the thing. And the efforts of President Hoover's Committee on Industrial Rehabilitation, headed by Chairman A. W. Robertson of Pittsburgh, organized to reach into every industrial community in the land and push to rebuild business gives the best promise for getting that needed start of any agency so far advocated or created.

For 3 yr., replacements and improvement in production equipment have been neglected in most plants, power and industrial. During that time, manufacturers of equipment have greatly improved their products as to efficiency and output, hence, the 55 per cent of equipment now in use that is 10 yr. or more old is practically obsolete and a handicap in competition with modernized plants. How can this handicap be removed? This is an individual problem for each executive, whether his responsibility be small or great.

First, study by every man of processes and equipment for which he is responsible or in which he is interested. Can the method be improved? What improvement in present equipment or in its arrangement or what new equipment will result in reduced cost or better product, which will pay for making the change? What equipment is available? Where can it be gotten and what will it cost?

In making such a study seemingly minor things may be important. Change in lubrication methods or lubricants; wrenches and tools to make proper adjustments; rearrangement of drives; fitting motors to their loads; these may be as helpful in getting better results as new generators or boilers. Practically no plant is without some need for tools or equipment to make operation more effective.

Not increase of installed productive capacity is the most important end to be sought, but more economical production and a better product. Organization so that each plant can get out of the red ink class with present or slightly increased volume of business is the immediate object.

The cost of changes and how to meet it! Well, some 80 per cent of the changes will cost comparatively little and firms have or know where they can get the funds. If all desirable changes cannot be made now, once they are listed and planned those which are most important or which *can* be paid for can be started, the rest taken care of as they can be financed. To know what's needed, then to get a start is the thing.

Why start? Because changes can be made and equipment purchased at 30 to 50 per cent less than 3 yr. ago and for less than they will probably cost after business recovers. Because operating under ineffective conditions of process or equipment increases the cost of product and reduces the possibility of sales. Because if everybody who can profitably do so would start modernization, the sum total of increased business would have a decided effect in starting the business-building circle. Because making the start will improve your own morale, stiffen your backbone and strengthen the will to do and succeed.

Everybody wants more employment, better business, a better outlook. Waiting for somebody else to do something never gets anywhere. It's up to each one to look over his own problems for progress and modernization. Then to get started.

Transporting Watts

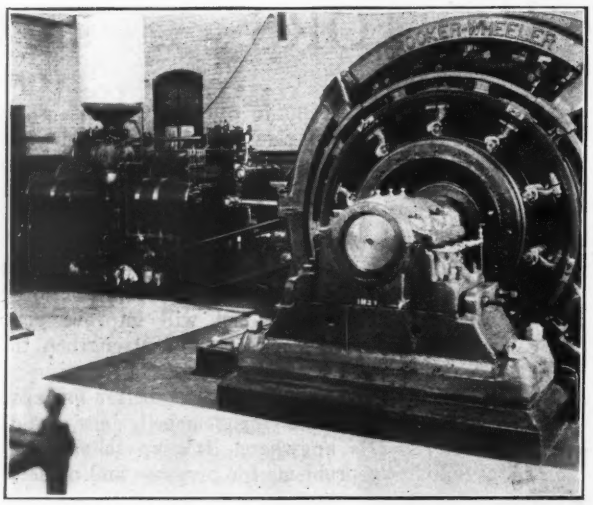
PACKAGING electric energy for transportation has not, on the whole, been satisfactorily accomplished up to now. Dry batteries are of small power and deteriorate rapidly. Primary wet batteries are sloppy, expensive and bulky. Storage batteries have been heavy, expensive, comparatively delicate and required frequent recharging.

With the Drumm storage battery, recently tried on the Great Southern Ry. of Ireland, results have been obtained that seem promising and may make possible electric vehicles to run independent of supply lines. If this or some other battery can be developed to allow long runs of electric vehicles and storage of electric energy in considerable quantities in batteries of light weight, a whole new field of development will be opened up.

Not only could the electric locomotive and automobile expand, but a service system for supplying customers off the regular distribution networks could be inaugurated, developing off-peak load for central stations to an unlimited extent.

This is not an immediate prospect, since 10 watt-hr. per pound of battery is the best present figure but, in view of what has been accomplished in reduction of weight of internal combustion engines per horsepower, it would seem that research might develop a means of packaging electricity which would make economical bulk transportation feasible. Certainly the benefits to be secured are worth the expenditure of considerable effort.

AUTOMATIC report of operating conditions is given over the telephone line from Pikesville and Townson automatic pumping stations of the Baltimore water supply system. On dialing the station, code signals of short and long buzzes and single strokes tell whether conditions are satisfactory, which of the two pumping units is operating, water pressure within 5 lb., water level within 1 ft.; if operation is unsatisfactory, code tells whether voltage is on the motors and whether protective devices have locked units out of service. Ordinary telephoning may be carried on with or by anyone who is at the station, the code signals being cut out when the receiver is lifted.



LYNCHBURG F

New Plant Built After a Thorough Investigation of Purchased Power. Present Prime Movers Operate Non-condensing in Order to Keep Cost at a Minimum but Provision Is Made for Condensing Equipment when Load Increases. Two 216-hp., 175-lb. Boilers and a New 600-kw. Unaflow Engine Set Installed

WHEN THE LYNCHBURG FOUNDRY CO. purchased the plant of the Virginia Iron, Coal & Coke Co. at Radford, Virginia, in 1907 to establish their Radford Works, the steam requirements were met with a battery of three 150-hp. boilers, and electric current was supplied by a 50-kw. engine-generator unit. Later when electric-driven hydraulic pumps and electric-driven air compressors were added to the plant equipment, the power plant was enlarged to meet the demands. Following these changes, an expansion program was carried out during which labor saving devices and plant equipment were added so as to increase production and permit larger castings. At the present time castings are made weighing up to 25 t.

By 1930, the power plant had become inadequate and portions of it were considered obsolete, hence it became necessary to consider means of meeting the increasing and more exacting power requirements. There were two ways open, the modernization of the present steam plant, or the purchase of power and the installation of electric conversion equipment.

Private Power Plant or Purchased Power

If the present power plant were to be modernized, it was felt that a rather simple medium pressure plant would be the most economical because of the low load factor and because of the rather cheap fuel available. With such a plan practically all of the present electric equipment could be kept for use as standby equipment and the only portion of the plant which would require complete renewal would be the boiler plant. As a result of this the fixed charges on the modernization could be kept rather low considering the value of the entire plant.

If purchased power were to be used, it would be necessary to install conversion equipment since the present electric system at the plant was entirely 230 v. direct current and only a part could be readily converted to alternating current. It was, therefore, necessary to consider either the installation of motor-generator equipment of sufficient capacity to serve the entire system, or the installation of motor-generator equipment for only the services which could not be converted to alternating current and the replacement of certain present direct current motors with alternating current motors. This would have necessitated an investment of about 30 per cent of the cost of the proposed modernization of the steam plant and burdened the purchased power plan with relatively high fixed charges in addition to the conversion losses.

Analysis of relative cost for service under the two plans showed that the total costs were about equal with a very slight margin in favor of the generation of power in a private plant, based on the use of exhaust steam from the electric generating equipment of the private plant for heating feed water only. Foundry practice requires a dependable supply of power and it was felt that the continuation of the private plant offered less risk of service interruption than the use of purchased power, because of the unavoidable effects of electric storms on power service supplied over a transmission line.

Use of exhaust steam from the steam driven electric generating equipment of the private plant for heating and some process work offered splendid possibilities for future development, which tended to favor the modernization of the present steam power plant. After a thorough study of the situation, it was decided to modernize the steam plant rather than to purchase electric power.

Old Power Plant

Equipment in the old power plant consisted of four 150-hp. hand-fired, return-tubular boilers generating saturated steam at 100 lb. pressure, and their auxiliaries; and two 200-kw. Corliss engine-generator units, one 150-kw. unaflow engine-generator unit, and one 50-kw. motor-generator set, furnishing direct current at 250 volts.

This power plant supplied electric energy for power and lights, and steam for heating and process service for the entire plant. The motor-generator set operated on purchased power was used at night and at times when the load was very low. The total maximum demand for electric current was about 525 kw. All of the equipment, with the exception of the unaflow engine-generator unit and motor-generating set were of antiquated design and pretty well worn out.

G FOUNDRY CO. Modernizes its RADFORD PLANT

By
W. E. ROYALL
Wiley & Wilson, Consulting Engineers
Lynchburg, Va.

Principal factors influencing the design in the modernizing of the present power plant besides the cost and economy factors always to be considered were: space limitation for boiler equipment, re-use of certain present steam using equipment, reliability, and provision for starting power plant mornings in case of failure of purchased auxiliary power service. Means for providing for each of these factors will be discussed in the description to follow.

Modernized Power Plant

After thorough studies, it was decided that the steam plant should ultimately consist of three water-tube boiler units each having a capacity of about 480 developed horsepower with superheaters and fired with pulverized fuel, to be located with auxiliaries in a new boiler house; electric generating equipment consisting of 600-kw. and 150-kw. unaflow engine-generator units operated condensing; a 200-kw. Corliss engine-generator unit operated non-condensing and a 50-kw. motor-generator set, operated on purchased power for use at night and during very low loads, located in the present engine room. One boiler unit and the condensing equipment for the two unaflow engine-generator units would be omitted for the present. The steam pressure and temperature operating conditions were set at 160 lb. per sq. in. pressure and 75 deg. F. superheat, so as to come within the safe limit of the 250-lb. standard for valves and fittings.

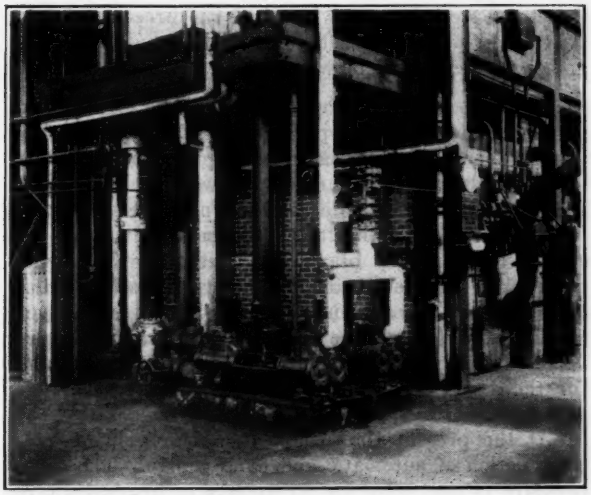


FIG. 2. TWO BOILERS ARE INSTALLED IN A BATTERY WITH SPACE LEFT FOR A THIRD UNIT

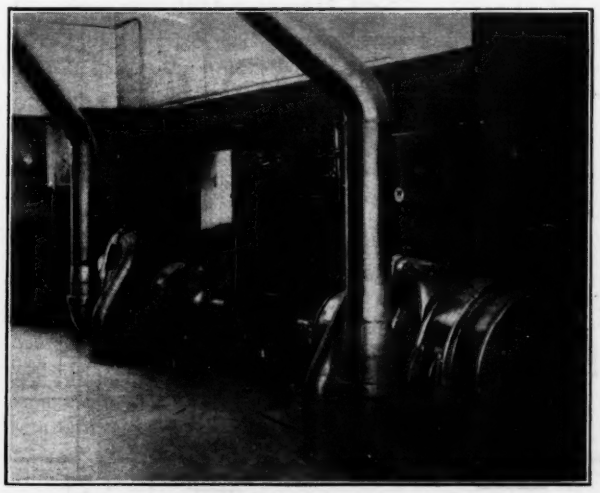


FIG. 3. PULVERIZERS AS INSTALLED IN FRONT OF THE BOILERS

Boiler Plant

Two Edge Moor 216-hp. water tube boilers of the bent-tube three-drum low-head design good for 225 per cent rating were purchased. These boilers were built for 175 lb. pressure and were equipped with integral water heating or economizer surface, superheaters of the convection type rated at 75 deg. F. temperature rise at 200 per cent of rating and Diamond soot blowers.

The firing equipment consists of unit coal pulverizers of the impact type driven by direct-connected electric motors and pulverized coal burners of the horizontal type. The two pulverizer units are of the opposite hand and are located so that a steam turbine can be installed between and direct connected to both units. This turbine drive will be required in the future for heat balance use in furnishing steam for feed water heating when the condensing equipment is installed for serving the two unaflow engines. The coal hoppers of the unit pulverizers are built against the outside wall and are arranged so that coal can be shoveled to them from the coal shed outside, as shown in the boiler room section.

Boiler furnace walls are of the sectionally supported air cooled type. Primary air for the pulverizers and burners is preheated by being drawn down the rear hollow walls and under the furnace floors. Secondary air is drawn down the side walls by natural draft and is

admitted to the furnaces through openings near the burners. The ashes are removed by hand from the furnace floors through large cleanout doors at the front, and the soot and fly ash are removed from the last pass of the boilers by soot ejectors and blown into the furnaces as also shown in the boiler room section.

Boiler plant auxiliary equipment consists of two reciprocating steam-driven duplex boiler-feed pumps located to the left of the two boilers and to the right of the space left for the future boiler and one direct-contact type cast iron feed-water heater located on a structural steel support with platform directly over the boiler feed pumps. Other auxiliaries include injectors, grease extractor and blow-off tank.

Welded Steam Line

High-pressure steam piping system, the boiler feed water connections and the blow-off piping were welded on the job, using steel flanges with welding hubs, bends and tube-turns. The water and low-pressure steam piping were installed with fittings, the flanged fittings being cast in the company plant. The steam supply connections to the injectors and soot blowers and soot ejectors of each boiler were made to the individual boiler connections between the non-return valves and the gate valves at the header so that steam would be available for these services from either the header or the individual boiler.

At the present time combustion is regulated by a combination of automatic and hand control. The steam pressure is controlled by an automatic hydraulic type master regulator which controls the coal feeders of the pulverizers. The amount of secondary air is controlled by hand operation of the uptake dampers with the assistance of draft gauges and a mechanical type CO_2 recorder. In the future it is contemplated to extend the automatic regulation to the control of the secondary air.

The quantity and temperature of the boiler feed water are measured and recorded by one combination flow meter and recording thermometer. Numerous indicating thermometers and pressure gauges give the other information required for operation. Flanged connections are left in the individual steam connections from the boilers so that steam flow orifices and meters may be installed in the future.

Engine Room

The present electric-generating equipment is located in a fairly modern and well constructed building with an overhead hand-operated crane. There was not sufficient room in this present building for the installation of the additional generating equipment and there was not enough space available for enlarging the building. It was, therefore, necessary to remove one of the 200-kw. Corliss engine-generator units, which was considered obsolete and no longer suited for continuous operation and in its place was installed a 28 in. by 36 in. Skinner universal unaflow engine of the poppet valve type direct-connected to a 600-kw., 250-v., 150-r.p.m., direct-current Crocker-Wheeler generator. This engine was a type which could be operated either condensing or non-condensing. The exhaust connections from the present engines were revised, and the exhaust from the old Corliss engine, left for standby service, was connected separately into the exhaust steam system. Exhaust lines from the two unaflow engines were connected together and arranged so that in the future they can be readily connected to condensing equipment and be operated

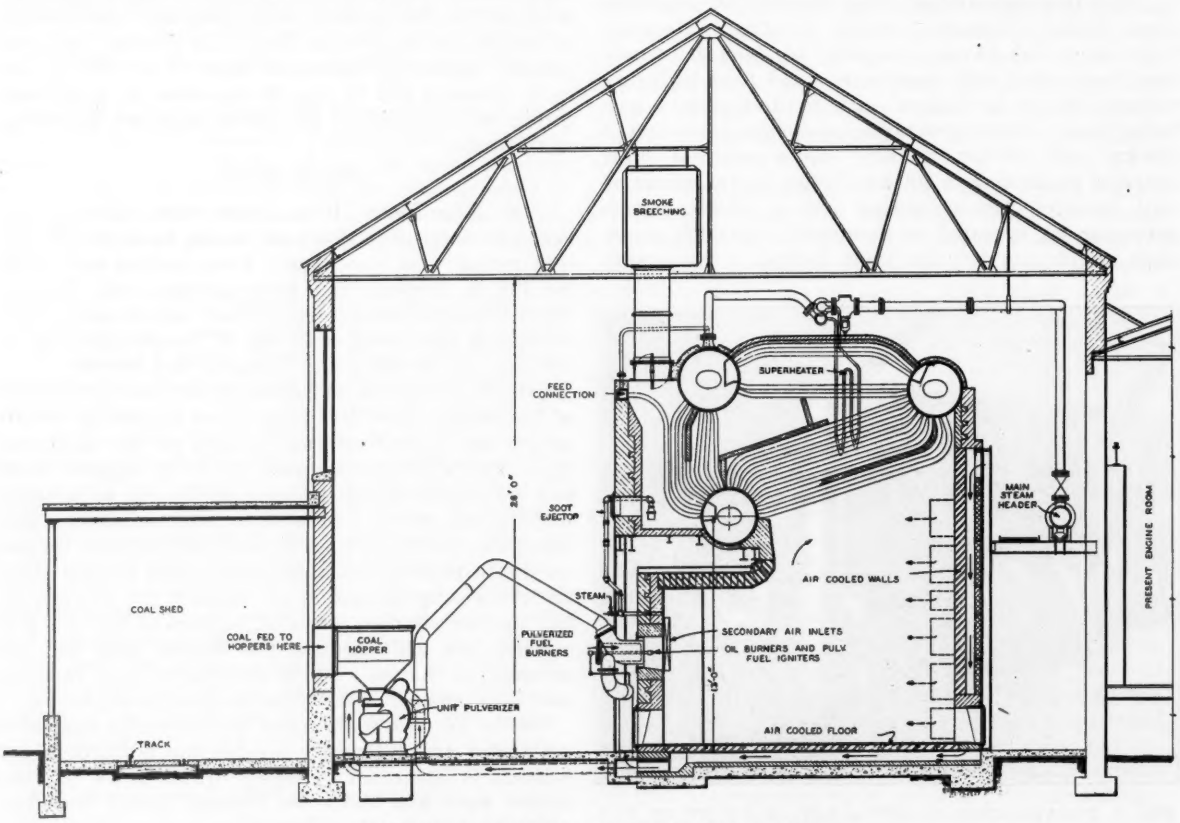


FIG. 4. CROSS SECTION OF THE BOILER ROOM

condensing. This will be done when the load increases to such extent that the savings in operating cost would justify the expense for condensing equipment. The two unaflow engines receive steam directly from the header at 160 lb. and 75 deg. F., but the steam supply to the Corliss engine, and other equipment is reduced.

Features of Plant

Careful arrangement of the boiler plant equipment gives a minimum of waste space as shown by the boiler room section. The boilers were installed reversed from the usual arrangement in order to permit the installation of the smoke breeching near the center of the boiler room where it could be installed in the roof trusses and thus permit a lower boiler house as well as to permit a boiler room of less depth while giving sufficient furnace length for the burner flame. The boiler arrangement as a whole makes an unusually neat appearance and has permitted very direct steam piping without its crossing the breeching. The main steam header is supported on I-beams at the rear of the boilers and in this location is accessible from the walkway installed on the same supports. Platforms are provided at two different levels at the sides of the boilers providing access to all drums, water columns, feed water regulators, and valves.

Generally it is not considered economical to use pulverized fuel for small capacity boilers, but in this case it was considered advantageous to do so in order to avoid heavy banking losses at night and better to burn an available rather low grade and cheap coal.

During the night the steam plant is shut down and a sure means must be provided for raising the steam pressure and putting the plant in service in the mornings. Under normal operation this is done by operating the coal pulverizers on purchased power with the use of the 50-kw. motor-generator set. Because the particular source of purchased power was not considered strictly reliable it was considered necessary to provide an additional means of putting the plant into operation in case of necessity. Oil burners were installed for igniting the pulverized coal and so the oil burners were purchased of sufficient size to bring the boilers up to pressure under no load when supplied with oil under pressure by a water-motor-driven pump. In case of failure of the purchased power supply, the plant can be put into operation by bringing the boilers up to pressure with the oil burners, putting the electric-generating equipment into service and starting the coal pulverizers quickly before the pressure drops too low.

It is believed that the reliability of the power service from the modernized plant is of a high order as most of the services are duplicated. For normal present loads, one boiler and the 600-kw. engine-generator unit are required. If for any reason the 600-kw. engine-generator unit is put out of service, the remaining generating equipment can carry all of the important load. Under present load conditions there is always one spare boiler and when the steam load increases to such an extent that two boilers must be continuously operated, an additional boiler will be installed for standby service. There are two boiler feed pumping arrangements each with separate connections to the boilers and with two separate sources of water supply. Under ordinary operation makeup water is drawn from the plant water system which is pumped directly from the New River nearby. In case of failure of this supply, water can be obtained from the City of Radford's system. Individual injectors are installed on the side of each boiler and discharge through separate connections to the individual blow-off lines from each boiler for emergency service.

General

In the actual reconstruction of this plant the entire work had to be handled so as not to interfere seriously with the foundry production. By careful scheduling of work, the peak loads were kept down to a point where three of the old boilers, two engine-generator units and the motor-generator set could carry the load. By the removal of one boiler it was possible to erect the two new boilers and to put one of them in operation. After the old boilers were removed the second new boiler was piped up and the new auxiliary equipment installed.

Erection of the major pieces of equipment was done under the direction of factory representatives, but the greater portion of the work and all of the piping was done by the plant forces under the direction of the master mechanic. This power plant was designed and its construction supervised by Wiley & Wilson, consulting engineers of Lynchburg and Richmond, Va. The actual construction work was handled under the immediate supervision of G. R. Elder, assistant plant superintendent of the Radford Plant of the Lynchburg Foundry Co.

Boilers—Edge Moor Iron Co. Two 216-hp., class BB-14 for low headroom, 3½-in. diameter tubes. Steam pressure 175 lb. sq. in. ga.
Superheaters—The Superheater Co. Two convection type to give 75 deg. F. superheat at 200 per cent rating.
Furnace—American Arch Co.
Pulverized Fuel Equipment—Fuel Efficiency Engineering Corp. Two size C Warrior pulverizing units, capacity 2000 lb. per hr. each, and two 9-in. Feeco burners and accessories. Two Schutte & Koerting Co. mechanical type oil burners. One water-motor-driven fuel oil pump.
Soot Blowers—Diamond Power Specialty Corp.
Feed Water Regulators—Stets Co.
Feed-Water Heater—The Cochrane Corp.
Boiler Feed Pumps—Worthington Pump & Machinery Corp.
Pump Governor—Northern Equipment Co.
Master Regulator—The Hagan Corp.
Engine—Skinner Engine Co. Universal Unaflow, 28-in. bore, 36-in. stroke, 150 r.p.m. driving a 600-kw., 250-v., 150 r.p.m.
Generator—Crocker-Wheeler Electric Mfg. Co.
Switchboard—Westinghouse Electric & Mfg. Co.
Instruments—Combination flow meter and recording thermometer, The Cochrane Corp. Draft gauges, The Hays Corp. CO_2 recorder, Ranarex, The Permutit Co. Pressure gauges and thermometers, The Foxboro Co.
Valves—Lunkenheimer Co.
Traps—The Strong, Carlisle & Hammond Co.

Measurement of particle size with an accurate air analyzer was described by P. S. Roller, associate chemist of the U. S. Bureau of Mines, in a paper before the 35th Annual meeting of the A.S.T.M. The essential features of this new apparatus for determining the particle-size distribution of fine powder by air separation and weighing of the fractions is that a U-container undergoes constrained oscillations in such a manner that the charge of powder is continuously brought into effective contact with the air jet by undergoing a combined translatory and rotatory motion.

Analysis into fractions 0 to 5, 5 to 10, 10 to 20, 20 to 40, 40 to 80 and 80 to 160 microns was made of four brands of portland cements and of three laboratory ground clinkers. It is found that the deviation of the recorded percentages is nearly the same for all the fractions and averages close to plus or minus 0.2 per cent. The time required for fractionation varies from 62 min. for the 0 to .5 micron to 11 min. for the 40 to 80 micron, total time of separation is less than 3 hr.

POWER PLANT ENGINEERING November 1932

Selection of Coal *to meet* Critical Conditions

By
JULIAN E. TOBEY
Chief Engineer of Power Plants
Studebaker Corporation

EXTREMELY high furnace temperatures covering a range of 2700 to 3100 deg. F. made the selection of coal of paramount importance in the subject plant whose fuel burning equipment consisted of large underfeed stokers. Due to the nature of its various services, the demand for continuity of service was 100 per cent. Burning coals unsuited for its particular requirements resulted in costly interruptions to service, abnormally high stoker and furnace maintenance, lowered efficiency and other kindred difficulties.

Inasmuch as this plant had a maximum consumption of 700 t. of coal per day it was readily apparent that the situation would justify an extensive study to determine what coal best suited its particular requirements. Consequently, about 7 yr. ago this problem was attacked in earnest, a complete coal testing laboratory including an ash fusion furnace was installed in the main power plant. Formerly coal samples were analyzed in the company's central laboratory but too much lost motion existed in this arrangement for several reasons to satisfy the situation.

The first revelation after this work was started was that the softening and fusion temperatures of the coal ash were extremely low and erratic. The writer wishes here to remark that, although seldom referred to, the softening temperature of the ash is really the important consideration rather than the fusion temperature, for trouble starts on stokers when the ash begins to soften and become plastic, as this promotes clinkering and interferes with the performance of the stoker.

Coal From Too Many Sources

It was found that the erratic behavior of the softening and fusion temperatures of the coals being burned was due to the mixing of different coals. A study of this condition revealed that there were at that time 16 different companies' coals on the approved list and that each company owned an average of four mines. This meant that coal was being received from some composite of 64 different sources and that the daily composite received was probably never twice alike. In addition to this, coal placed in storage was again subjected to the hazard of further mixing.

This hodge-podge of fuel made good combustion results impossible. The chemical constituents of the various coals seemed to clash and have an unbalancing effect on the combustion of the fuel. This resulted in coking, caking, softening, clinkering and cracking of fuel beds. This in turn disturbed the distribution of air through the stoker causing abnormally hot spots in the fuel bed. The air instead of properly percolating through the fuel bed and sustaining combustion uniformly over the entire area of the stoker came through cracks or fissures at a high velocity creating a blowtorch action in spots which produced local temperatures far in excess of the ash fusion temperature of any coal.

Looking at it from another angle the fuel bed instead of being a porous monolithic structure was made up of rather large masses separated by vertical crevices. The air, instead of penetrating these masses and producing normal combustion, came through the crevices and resulted in surface combustion in the crevices causing them to become wider especially at the bottom and to cavitate, for combustion proceeded most rapidly at that point where the air first made contact with the fuel. This action proceeded until the masses of fuel were actually burning underneath and reflecting a terrific heat and flame directly on the stoker castings and simultaneously depositing molten ash on the castings thus stopping the air openings in the grate. This com-

As the outcome of this rather intensive study, covering a period of 7 yr. during which time several thousand coal and ash analyses were made and over a million tons of coal consumed in this one particular plant, the author has formulated the following precautions:

1. **Do not mix coals.**
2. **Do not change from one coal to another during peak loads.**
3. **Do not attempt to burn a coal having an ash fusion temperature of 2000 deg. F in a 3000 deg. F. furnace.**
4. **Determine size of coal best suited to stoker.**
5. **Never fool the fireman; tell him exactly the particular coal he is burning.**
6. **Do not store coal on sand or other material which will by contamination affect the fusion point of the coal ash.**
7. **Generally, the proper coal is the most economical coal to burn, price being of secondary importance.**

The benefits from the careful selection of coal are legion, Following are a few of the greatest importance:

1. **Burning coals straight (avoiding mixtures) eliminates many variables which adversely affect costs.**
2. **Coals which are best suited to the stoker permit long continuous operation, thereby reducing outages and loss of stand-by capacity. This in turn makes available more boiler horse-power without increasing capital investment.**
3. **Improves continuity of service.**
4. **Reduces maintenance costs and permits a more systematic control of maintenance.**
5. **Increases the flexibility of the stokers and permits operation at higher ratings.**
6. **Produces higher efficiencies.**
7. **Makes a contented operating personnel. This is of vital importance for the fate of the coal pile rests strictly in their hands.**

bination not only destroyed the castings but caused clinkers to form and freeze on to the stoker making it necessary for subsequent fuel to avalanche over this formation. This type of clinker always formed at the lower end of the stoker and would then grow toward the upper end. This would proceed until after a few hours the stoker became so unmanagable that it was necessary to take the boiler off the line to clean off the stoker and replace the damaged castings.

Another bad feature of burning mixed coals was that the stoker fireman never knew with what combination he had to deal, consequently he had no definite plan for adjusting his stokers to meet peak load demands and other load changes. He was in the dark as it were and the steam pressure thereby suffered.

In view of the above experiences it was decided to obtain coal from fewer sources and keep the various coals separated. Each company from whom coal was purchased was instructed to ship its quota from one mine and accordingly to furnish bills of lading on the shipment. The coal storage yard was laid out in sections allotting one section to each particular mine and thus marked with a suitable sign. The storage bunker in the power plant was also divided into three sections, each section having a capacity of approximately 600 t.

W. Virginia and Kentucky Coals Tried Out

It soon became apparent that midwestern coals had too low ash fusion temperatures to meet the requirements of these particular stokers and furnaces. It was then decided to try eastern coals (W. Va. and Kentucky). The first coals received from these fields, although they had higher ash fusion temperatures than the midwestern coals, were still too low to satisfy the situation. The ash softened at 2000 to 2300 deg. F. The eastern Kentucky coals generally were of a freer burning nature than the western West Virginia coals, but unfortunately were lower in ash fusion therefore it was necessary to sacrifice this desirable feature in lieu of obtaining coals with a higher ash fusion characteristic.

Selection of coals was more specific after it became apparent that considerable diversity in ash fusion temperatures existed even in coals from these fields. The process consisted of the cut and try method and the elimination of all coals (good and poor) which did not meet this one requirement. No specifications were drawn up for the selection of coals with the exception that the ash should not fuse below 2700 deg. F. nor soften below 2550 deg. F. It was then understood if a coal met the fusion requirement it must also give satisfaction from a standpoint of steam production and maintenance.

It is mentioned here that it was found that a coal having ash of high fusing temperature is generally a good coal although the converse is not true, for many good coals have low fusing ash. Many excellent coals tested were below par in this respect and were necessarily discarded for use in this particular plant.

The general procedure for testing a new coal source consisted of first learning the exact location of the mine and ascertaining its facilities (method of mining, output, etc.), then to study the general characteristics of coals mined in that territory. If this information appeared favorable, a sample of the proposed coal was procured and analyzed. If this sample had the earmarks of a coal suitable for the plant requirements, a purchase order was issued for 5 or 10 carloads. On

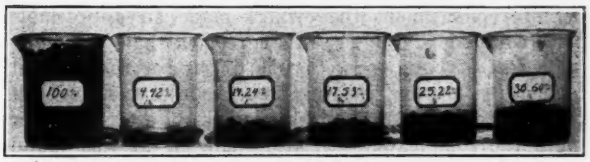


FIG. 1. SMALL COAL SAMPLE PROJECTED INTO SEVERAL COMPONENT SIZES; SIX SAMPLES WERE CLEAN-SCRAPED ACROSS THE CONVEYOR BELT FROM EACH OF FIFTEEN 50-T. CARS

receipt of this lot, it was given the right-of-way through the coal handling system and fed into the stokers and the performance on the stokers was carefully observed. If the stokers appeared to thrive on it an order was then issued for a 50 or 100 car lot of the coal. It was from this larger lot that data was obtained showing its performance from a standpoint of steam production and maintenance.

One Source of Coal Selected

In spite of the fact that discretion was used in selecting coals for tests and only those coals used which appeared to be in line, an actual average of five out of every six coals tested failed to meet the requirements. Over a period of 3 yr., coals from 120 mines were tested according to this program and only 20 were found to be acceptable and placed upon the approved list. Out of these 20 coals only six were outstandingly preferable. Inasmuch as it had been the policy to purchase coal on a monthly spot market basis it was seldom that more than two or three of these sources were available at a time. Previously, as has been mentioned heretofore, it was proven to be bad practice to mix coals, as it seriously affected their burning qualities and the performance of the stokers and it had been found that it entailed considerable expense to keep the coals segregated. As a result it was decided to enter into contract for a one

FIG. 2. PILES OF SIZED SAMPLES VISUALIZING PROPORTIONATE AMOUNTS

source coal supply. Accordingly, a coal was selected from a certain mine which had proven satisfactory from every standpoint and which had already supplied approximately a quarter of a million tons to this plant. On the face of it, this probably appears to have been rather a bold procedure; however, such was not the case and it proved to have additional advantages.

Considerable study was given the selection of this mine and source. It was found to be a large mine located in a large seam. It had a remarkable continuous operation record. If for any reason this mine should shut down the operators owned and operated five other mines in the same seam and field. When assured of a large

definite commitment the owners made an appreciable price concession. In fact, this agreement had a stabilizing effect at both ends, that is to say, at the mine it tended to improve the mining schedule and made it possible to increase shipments quickly. At the power plant the complexion was also changed. It was found that with one company solely responsible by contract to supply the coal as needed, it did a better and more uniform job than did several companies attempting to supply the fuel.

When operating on the multiple source basis it was necessary to provide greater storage. This occasioned more coal handling expense due to reclaiming. Thus more money was invested in coal and the interest lost

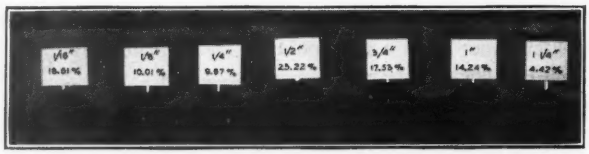


FIG. 3. BROKEN DOWN INTO SEVEN COMPONENT SIZES, THE SAME COAL SHOWS A DIFFERENT PICTURE

was greater, also in having to store and reclaim coal there was a certain shrinkage loss.

With the inauguration of the one source coal supply these objectionable features were eliminated and, too, the coal burned was in a fresher state which was beneficial from a combustion standpoint.

Factors Affecting Savings

It is obvious that this system saved money for both the vendor and the consumer and was psychologically a perfect bargain. After one year's operation on the one source coal plan, a check up showed an accumulated saving of approximately 10 per cent over previous year's operation. As approximately 100,000 t. of coal were involved this saving amounted to about $40,000 and was accounted for by reductions in costs of the following items:

Coal yard and boiler room labor, evaporation, locomotive crane service, crushing expense, switching charges, stoker repairs and interest on money invested in storage coal.

The first two items were by far the most important and produced the bulk of the savings.

An appreciable increase in evaporation was enjoyed for it was found that the firemen got more out of a certain coal when burning it continuously day after day. In other words there was a noticeable improvement in their firing technique.

Coal Sizes and Stoker Performance

After the question of coal supply had been successfully disposed of, the matter of coal size and its effect on combustion and stoker performance next claimed attention. Coal of various sizes had been burned but due to the fact that different sources had furnished different sizes in the past it was confusing and difficult to interpret the actual effect of size as no two coals have the same burning characteristics and seldom do coals listed at the same size have the same relative proportions of coarses to fines, as this is influenced by the structure of the coal whether hard or soft. Tests were made on the same coal using the following sizes: Mine run (crushed to 1¼ in.), 2-in. nut (crushed to 1¼ in.), 2-in. nut, pea and slack and 1¼-in. nut, pea and slack. Of all sizes tested the 1¼-in. nut, pea and slack proved to be the most satisfactory size for use on the underfeed stokers under all conditions of load ranging from banked fires to 350 per cent of normal rating. These tests of coal sizes were really a study of fuel bed porosity and it was surprising to learn that the 1¼-in. nut pea and slack which visibly contained a high proportion of fines proved to have such flexibility.

Following this series of tests which determined the proper basic size of coal to use, a study was made of the gradation or component sizes making up the 1¼-in. nut pea and slack.

A composite sample, amounting to approximately 1½ t., was carefully obtained from a total of 750 t. of coal and given several screen tests. The results of these tests are illustrated visually by the illustrations. Figure 1 simply shows a small sample projected into its several component sizes.

Table I applies to sizes as shown in this photograph and all samples for analyses were taken from these piles. A study of this tabulation reveals several interesting things: 1. The greatest percentage of coal was found in the ¼-in. size. and naturally the lowest percentage occurred in the 1¼-in. size. 2. The quality of the coal in the ¼-in. size was remarkably high, indicating that the regular coal was free from impurities otherwise dirt and other foreign material would have appeared in greater amount in the fines. This also reflects clean mining and the fact that the mine must have a good firm roof and floor condition. It is to be noted that the ash fusion and softening temperatures

TABLE I. VARIATION OF COAL QUALITY WITH SIZE OF PARTICLES

Size of Coal, in.	1/4	1/2	3/4	1	1-1/4	Regular Sample 1-1/4 N.P.& S.
Per cent of Size	38.60	25.22	17.53	14.24	4.42	100.00
Moist-removed by Oven	.96	.93	.99	1.07	.75	1.14
Volatile Combustible	33.63	35.11	34.75	34.70	36.55	33.02
Fixed Carbon	58.72	57.49	56.70	57.64	56.70	59.60
Ash	6.69	6.47	7.76	6.58	6.00	6.24
Sulphur Per cent Sep.Determ.	.65	.68	.70	.68	.62	.62
B.t.u. Dry by Calor.	14434	14311	14280	14353	14595	14565
Fusing Temp.of Ash deg. F.	2600	2650	2900	3050	2875	2760
Softening " " " " "	2200	2575	2710	2810	2760	2550
Fluid Temp. " " " "	2700	2725	2850	3060	2960	2860

are lower in the ¼-in. and ½-in. sizes than in the regular sample, however, this is not surprising for naturally there will be some contamination in the fines. It is interesting to note how little of such contamination it takes to reduce these temperatures as denoted by a comparison of the ash content of these sizes as against the ash content of the regular sample, also that the effect was greater on the softening point than on the fusion point.

Sand in the Coal

To illustrate this point further, at one time a most reliable coal suddenly began to give trouble; analysis showed that the fusion point and softening point of the ash had dropped. The softening temperature was particularly low having been more affected than the fusion temperature. After considerable investigation the trouble was located at the mine. The mine operator

reported the source of the trouble. He stated that it was due to contamination by track sand. This coal came from a drift mine and the tracks were laid on a rather steep grade. In order for the locomotive to bring the mine cars out to the tipple it was necessary to sand the tracks heavily. He found that the laborers whose duty it was to clean up the coal which accumulated along the sides of the track (due to spillage from the cars) were using shovels instead of forks for handling the coal and were getting the track sand mixed into this coal. With the result that it was seriously affecting the fusion and softening point of the coal ash even though the amount of such contamination was relatively small.

Figure 3 shows the same coal broken down into seven different component sizes. The ½-in. size shows the

FIG. 4. SPLITTING THE COAL INTO TWO SIZES GAVE 64 PER CENT THROUGH ½-IN. MESH AND 36 PER CENT OVER ½-IN MESH

greatest proportion (25.22 per cent) whereas the next size in order is the 1/16-in. (18.61 per cent). It was quite surprising to find such a preponderance of fines in this coal which burned so satisfactorily.

Figure 4 shows the same coal split two ways, that which passed *through* a ½-in. mesh screen and that which passed *over* the same screen. It is to be noted that nearly twice as much was under ½-in. size as was above this size.

No attempt here is made to set up a standard method for the selection of coal for all underfeed stokers; rather this is a compilation of facts and findings focused on one plant in which most of the fuel burning equipment consisted of large underfeed stokers minus clinker grinders and other modern facilities. While high furnace temperatures have been mentioned, to be specific, the troublesome temperatures existed at the lower end of the stoker. In that zone the temperatures varied over a range (dependent on ratings) from 2700 to 3100 deg. F. It was in that zone that most difficulties were encountered with the various coals.

Regarding furnace maintenance, due to the fact that the coal selected had a low sulphur and iron content and the fusion temperature of the ash was high, repairs to brick work were reduced to a minimum. In fact the burning of this grade of coal produced a dry honeycomb type of deposit on the brick which served as a protection to the refractory. Therefore there has been little if any chemical deterioration of brick. Many of the boilers still have their original side walls (solid type), except for minor patching along the stoker line, after approximately 7 yr. of severe service.

The gas passages of the boilers stay remarkably clean, there is no front row tube slagging, thus heat absorption maintains at a constant rate throughout the entire run of the boiler. This is reflected in extremely uniform flue gas temperatures and of course, best of all, higher average boiler and furnace efficiencies.

Boulder Dam, Hydroelectric Control

By A. P. Connor*

Some time ago, the United States Bureau of Reclamation issued statements indicating that the power development of the Boulder Canyon Project, also known as Hoover Dam, would be 1,000,000 hp., making it the largest hydroelectric development in the United States and possibly the world. Latest developments indicate that the installed capacity of the power plant will be 1,200,000 hp. made up of generator units of 115,000 hp., which will be far the largest in the world, as present largest units are about 52,000 hp. Specifications for these units, which will be ready some time in October, are being made up in Washington, D. C., and at Denver, Colorado. The maximum height of the dam above foundation rock will be 730 ft. and about 582 ft. above the water level of the river. It will be 45 ft. thick at the top and 650 ft. at the base. Length at the crest will be about 1180 ft. Power development will be in three plants, one at the bottom of the dam, one further down the river on one bank and the third on the other bank, with the discharge water being diverted downstream, and not at right angles into the river as heretofore shown and stated by the department.

Federal Power Commission has issued a book dealing with holding company interests of power utilities, which will contain 150 pages and supposedly much information of value to those who are interested in tables and statistics. It is indicated that the report deals largely with the control of hydroelectric utilities by holding companies and the effect this has on prices for the sale of current; also suggests that the powers of the Federal Power Commission be extended to give control of such holding companies, and that Congress give such power "to the fullest extent possible in the enactment of legislation stopping these loopholes in public control of electric public utilities." From the report it would seem that the Federal Power Commission intends that public utilities shall be fully subdued in every way.

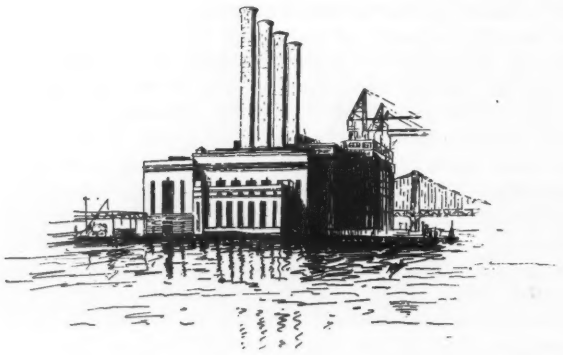
*Special Washington Correspondent.

Gray cast iron, unlike other structural metals, is not a homogeneous mass but consists of countless small graphite flakes imbedded in a metallic matrix, this matrix being essentially similar to a high carbon pearlitic steel. The mechanical properties of gray cast iron vary not only with variations in composition but in an iron of a given composition these properties vary widely with different size of sections.

To determine the effect of size of specimen on the mechanical properties of cast iron a comprehensive test was made of one melt of iron. Specimens tested ranged in size from the standard A.S.T.M. tension bar to one 4 in. square. In general it was found that tensile strength and hardness decreased while deformation per unit stress increased with increasing size of specimen.

The results of this investigation are given in Bulletin 72 of the Engineering Experiment Station, The Ohio State University. Variations in elastic properties of the various specimens are shown by several sets of curves while variations in structures are shown in a complete set of micrographs. The bulletin may be obtained without charge on application to the Director of the station.

World's Largest Condensers at Hudson Avenue



101,000 Sq. Ft. Units Serve 160,000-Kw. Units Nos. 7 and 8 at World's Largest Station. Condenser Surface 0.631 Sq. Ft. Per Kw. Each Unit Requires 200,000 g.p.m. Condensing Water.

WHEN THE INITIAL SECTION of Hudson Ave. Station of the Brooklyn Edison Co. was built in 1923[1] with two 50,000-kw. units, the ultimate capacity of the station was placed at 400,000 kw. When the station was finished this summer[2] the capacity was 770,000-kw., making it the world's largest steam station. In spite of the increasing size of units from 50,000 to 80,000 to 110,000 and finally to 160,000 kw., the original station plan of eight units each with four boilers has been followed throughout the course of development.

Suction and discharge circulating tunnels for the entire plant were installed with the original section as indicated on the plan of the station. They were, of course, laid out on the basis of eight 50,000-kw. units and so to maintain reasonable velocities in the tunnels it was necessary to limit the water to each of the condensers, 200,000 g.p.m. or about 1.25 gal. per kw. of capacity being the limit for the new 160,000-kw. units.

Another limitation was the space available, imposed at one end by the feedwater piping and space for feedwater heater tube renewals; at the other end by the fixed location of the circulating pumps and condenser tube removal space; and at the top by the turbine room floor which it was not practicable to raise more than 5 ft., making the distance between the turbine room floor and basement floor 39 ft. as compared to 34 ft. for the first six units installed in the station. Space between the turbine foundation columns was 22 ft. 8 in. for No. 7 unit and 24 ft. 8 in. for No. 8 unit.

Condenser Specifications

Beyond the space and water limitations the specifications placed no limitation on surface, number of water passes, or tube length, except that the condenser should maintain an absolute pressure of not more than 2¼ in. of mercury with a heat rejection to the circulating water of 1180 million B.t.u. per hour, with 73 deg. F. circulating water. Heat transfer coefficients were based on 70 per cent of the heat transfer for commercially new clean tubes. Facilities for determining the heat transfer under normal operating conditions are provided by installing six groups of five tubes each, which can be isolated by hose jumpers connected through special covers in the waterbox manholes. In addition, the specifications gave the effect of vacuum on the heat consumption, steam values and the basis by which the condenser performance would be evaluated.

Number 7 condenser was supplied by Worthington and No. 8 by Ingersoll-Rand. Both are single shell, single pass units, containing 101,000 sq. ft. of active surface. Each unit has two 42-in. atmospheric relief lines which change from a circular section at the valve to an elliptical shape at the top of the condenser shell as shown by Fig. 3. This elliptical shape was necessary because of 89-in. girders in the turbine foundation.

Both condensers are bolted directly to the 20 ft. 10 in. by 20 ft. turbine exhaust opening and the load, above the 500,000-lb. maximum allowable operating load on the turbine exhaust, is carried by springs. Auxiliaries for each unit were supplied by the respective manufacturers. Circulating and hot-well pumps driven by two-speed motors are in duplicate. Two-stage steam jet air removal units are used for normal operation with two single-stage hogging jets for starting. In contrast to the other units in the station, no valves are installed in the circulating water system although the water boxes are so divided that half of the condenser may be taken out of service and cleaned while the unit is in service.

Unit No. 7

Number 7, the Worthington unit, has a cylindrical shell and an active surface of 101,000 sq. ft. including air cooler sections which comprise about 6 per cent of the total surface. The tube sheet arrangement is shown at the right of Fig. 2, the surface being made up of 14,710 ⅞-in. O.D. No. 16 B.W.G. tubes 30 ft. effective length. Tubes are packed at both ends with fibre packing rings and Admiralty metal ferrules. Except for a few experimental tubes of special alloy, all tubes are of Admiralty metal.

[1] See Power Plant Engineering, p. 177, Feb. 1, 1923, and p. 549, May 15, 1924.
[2] See Features of New Hudson Ave. addition, Power Plant Engineering, p. 334, Apr. 15, 1931.
[3] See Power Plant Engineering, p. 251, Feb. 15, 1931, for a development of this design.

Tubes are arranged in accordance with the Worthington double folded tube layer principle[3], comprising two symmetrical banks of tubes, one on either side of the vertical center line, each bank consisting of a band or layer of tubes folded upon itself somewhat in the form of an inverted U, the inner portion of which forms

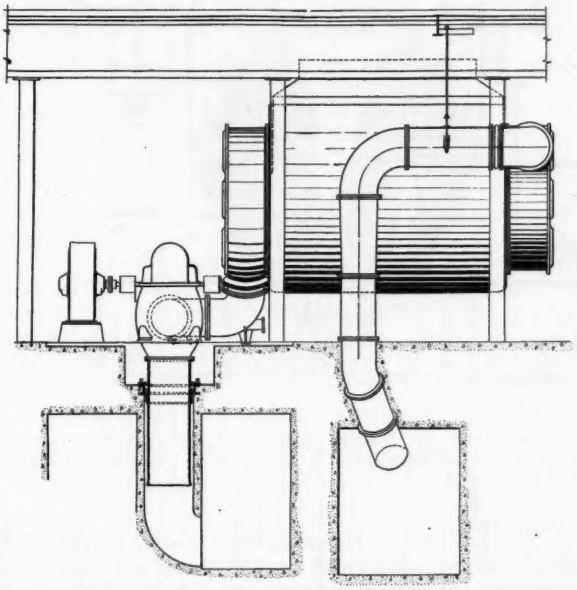


FIG. 1. TYPICAL LONGITUDINAL SECTION OF CONDENSER CIRCULATING WATER SYSTEM

an exit lane leading to a secondary or air cooler section near the bottom of the shell.

There are two inner air cooler sections, one on each side near the bottom of the shell. Suitable baffles separate the cooler sections from the remainder of the tube bank, these baffles being formed of double plates with a dead air space between to prevent transfer of heat from the steam side to the air cooler.

Condensate is drained from the cooler baffles by means of brass pipes spaced at intervals, thus preventing a continuous sheet of condensate which would cause heating of the air passing through the stream. Suitable baffles are also provided at the bottom of the shell to promote thorough mixing with exhaust steam, resulting in perfect heating and deaeration before it flows to the hotwell. Tube heads are of Muntz metal 21 ft. in diameter by 1 7/16 in. thick, machined both sides and cut off top and bottom to 17 ft. 3 in. and were made in quarters, which necessitated longitudinal and transverse braces of structural steel.

Tubes are supported by six intermediate support plates of Muntz metal ¾ in. thick. All interior baffles were made of the same material ⅛ in. or more in thickness. Open nature of the design lends itself well to practically 100 per cent accessibility to the steam space and tube banks. A manhole at the hotwell permits entrance to the central steam passage and a ladder permanently installed permits a man to climb directly up into the exhaust connection. A man can likewise walk upright the full length of the central passage, or the full length of each lane to inspect cooler tubes, baffles and drain pipes, all made possible by the support plate cut-outs.

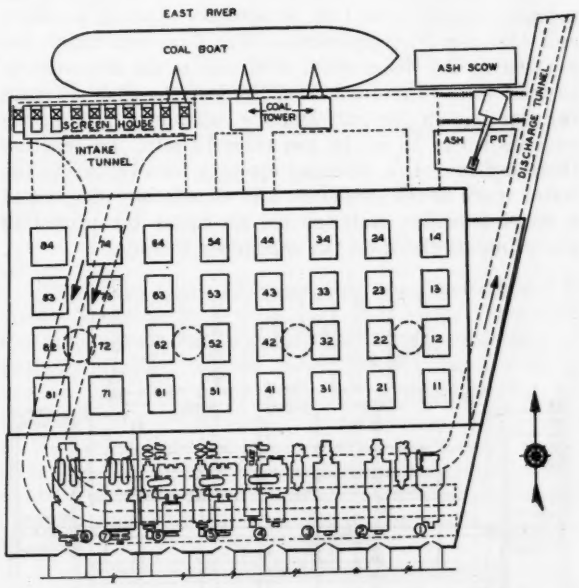
The condenser has an overall length of 41 ft., a height of 33 ft. 4½ in., a width of 22 ft. 5 in. and a total service weight of 1,113,000 lb. The center line of the shell is offset 15½ in. from the center line of the turbine in order to make possible a shell length of 30 ft. Inlet and outlet water box nozzles are elliptical in shape, 58 by 54 in. in diameter. The hotwell is cast in one section and bolted to the condenser. In addition to this 800-gal. hotwell an emergency storage of 5000 gal. is available in the condenser shell below the tubes.

Auxiliary Equipment

Two horizontal bottom suction, volute circulating pumps are provided, each driven by a 600/250-hp. 40-deg. C., 2300 v., 3 ph., 60 cycle constant speed full voltage starting squirrel cage motor. These pumps are rated at 73,250 g.p.m. against 24 ft. total dynamic head at a speed of 220 r.p.m. or 48,500 g.p.m. against 14 ft. total head at speed of 160 r.p.m. At mean low water there is a static water column of 33 ft. The syphon effect will give nearly full recovery. At extreme low water the static water column is about 36 ft. with a loss of somewhat over 3 ft.

Condensate pumps are also installed in duplicate, each pump being driven by a 225/115-hp. 40 deg. C., 2300 v., 3 ph., 60 cycle, 900/720 r.p.m. synchronous two-speed full voltage starting squirrel cage induction motor. At the high speed, pumps are rated at 3000 g.p.m. against 180 ft. total dynamic head and at the low speed, 2000 g.p.m. against 130-ft. head. In contrast to the journal bearings and rigid couplings on the circulators these pumps have ball bearings and all metal lubricated flexible couplings.

The steam jet air ejector assembly consists of a triple



PLAN OF STATION AND WATER TUNNELS

element two-stage steam air ejector with surface inter and after coolers, precooler and two 6-in. single stage non-condensing evacuators or hogging jets. The precooler contains 56 sq. ft. of active surface and is supplied with salt water from the circulating system whereas the inter and after coolers are supplied with condensate, being designed to handle the total flow at

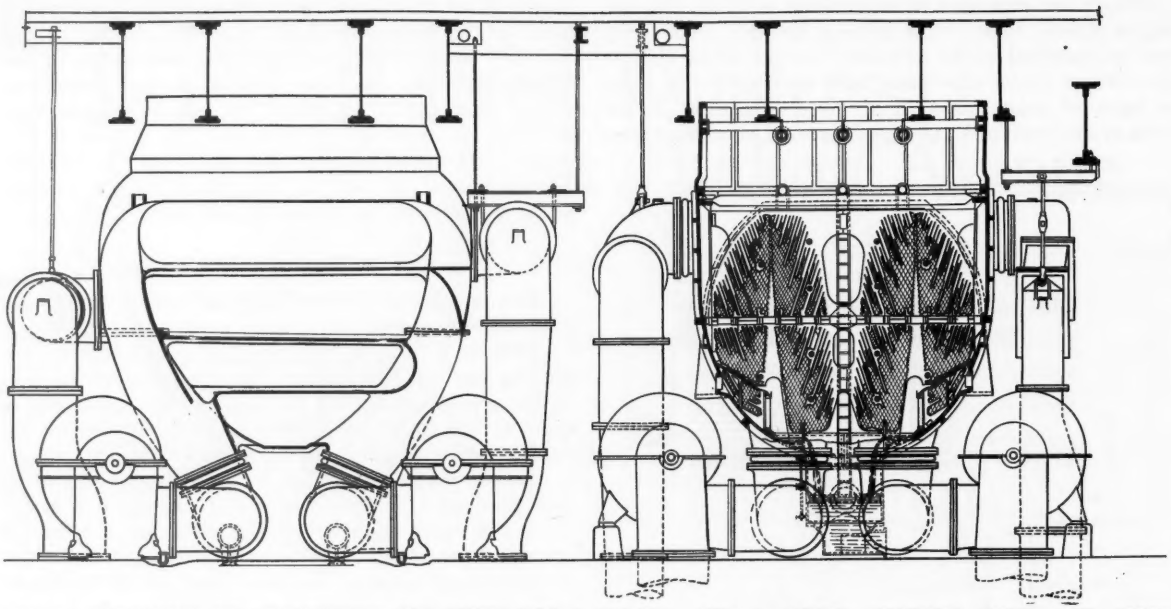


FIG. 2. ELEVATION OF CONDENSERS FOR UNITS NOS. 7 (RIGHT) AND 8 (LEFT) SHOWING PUMP AND PIPING ARRANGEMENT. NUMBER 7 SHOWS TRANSVERSE SECTION THROUGH STEAM SPACE AND NO. 8 TRANSVERSE SECTION THROUGH WATER BOX.

maximum load on the turbine without bypassing. A precooler was furnished in this case for the purpose of compensating for any heat which may be absorbed from the surrounding atmosphere by the long suction connection between the air cooler sections in the main condenser and the steam jet air ejector unit. The three elements have a total capacity of 33 cu. ft. of free air per min. saturated at 1 in. of mercury absolute pressure and 71.6 deg. F. temperature. The 6-in. evacuators for exhausting the steam space discharge to the atmospheric exhaust lines. These materially reduce the time required for starting up the unit and are capable of pulling the vacuum up to 15 in. in less than 15 min. In addition there are four 4-in. priming ejectors for evacuating the water space of the condenser and circulating pumps and a multiple-orifice, water-cooled air meter for providing a continuous check on the condenser leakage.

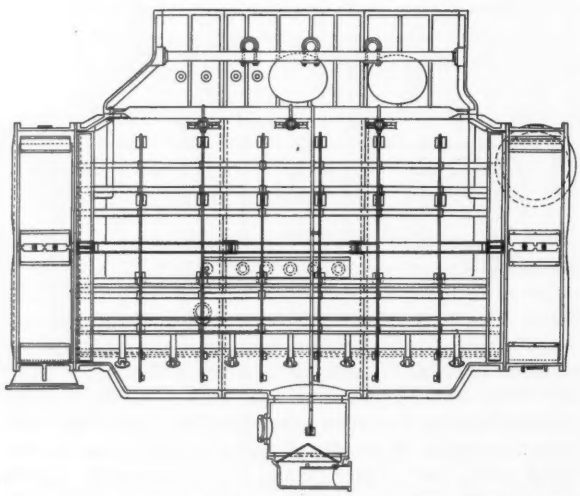


FIG. 3. LONGITUDINAL SECTION OF WORTHINGTON CONDENSER FOR UNIT NO. 7.

The unit No. 8, Ingersoll-Rand condenser design is heart shaped, subdivided on the steam side into four horizontal banks extending across the condenser and into five compartments along the length of the condenser; on the water side into four horizontal superimposed compartments. Not all the steam enters the uppermost tubes of the tube bank as part of it is bypassed directly to two points lower down in the tube bank by by-pass compartments extending the entire length of both sides of the condenser.

A rectangular hotwell at the bottom of the condenser collects the condensate while vapor and air turn and flow through multiple nozzles to an external cooler supplied with circulating water. To reheat the condensate to nearly the full temperature of the turbine exhaust, a 1600 sq. ft. reheater section is made by partioning off a section of the bypass to the lower tube bank.

Longitudinally the condenser is divided into five compartments by four support sheets which are made tight in the shell. The hotwell at the bottom has correspondingly tight partitions. Condensate flows from one compartment to the other through sealing traps T, Fig. 4, and is finally removed from the hotwell through two condensate outlet nozzles.

Design of water boxes is shown in Fig. 2. One pump supplies the first and third circuits, the other pump the second and fourth circuits. Space limitations required building the inlet pipes as part of the boxes. The second water circuit is 5 ft. lower in elevation than the top circuit. In the present case, the highest tubes are about 36 ft. above extreme low water. With the design shown, the upper circuit at lower tidewater, exceeds the theoretical syphon, with a consequent increased head on one circulating pump while the lower circuit at the 5 ft. lower elevation remains within it. One pump can also be run at reduced speed while the other pump is operated at full speed. Under intermediate load and water temperature conditions this results in a power saving. The arrangement also tends to decrease tube

corrosion, tending to prevent rapid formation and agglomoration of air bubbles and their concentration in the higher circuits.

Dimensions and Auxiliaries

This unit has an overall length of 42 ft. 9 in. and a total service weight of 1,326,270 lb. There are 14,550 7/8-in., No. 16 B.W.G. tubes 30 ft. effective length, giving an active surface in the shell of 100,000 sq. ft., which with the 1000 sq. ft. active surface in the external cooler gives a total surface of 101,000 sq. ft. The steam jet equipment consists of two duplicate units of first and second stage ejectors, each unit consisting of 8 primary jets and 3 secondary jets with inter and after cooler. Specified capacity of each unit 30 c.f.m. saturated at 1 in. abs. and condenser temperature. A displacement type air meter is connected to these units. In addition there are two 8-in. starting jets for evacuating the steam space of the condenser and four 8-in. priming jets to evacuate the circulating water system.

The circulating water pumps are two in number, each being driven by a 600/180-hp., 40-deg. C., 2300

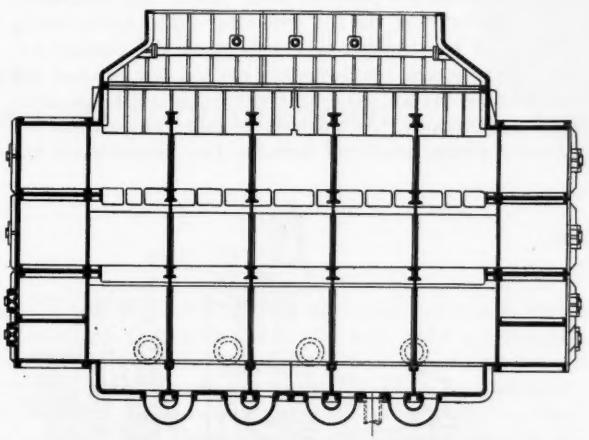


FIG. 4. LONGITUDINAL SECTION OF INGERSOLL-RAND CONDENSER FOR UNIT NO. 8

v., 3 ph., 60 cycle constant two-speed full voltage starting squirrel cage motor. The pumps are horizontal, having bottom suctions the same as the Unit No. 7 pumps. At high speed the pumps are rated at 72,750 g.p.m. against 25 ft. total head at 192 r.p.m. and at the low speed of 128 r.p.m. they are rated at 48,500 g.p.m at 11.5 ft. total head.

The condensate pumps are also in duplicate, each being driven by a 225/115-hp., 40-deg. C., 2300 v., 3 ph., 60 cycle, 900/720 r.p.m. synchronous two-speed full voltage starting squirrel cage induction motor. At high speed the pumps are rated at 3000 g.p.m. against 190 ft. total head and at low speed 1900 g.p.m. against 128-ft. head. Both the circulating and condensate pumps have journal bearings and all metal lubricated flexible couplings.

Replacing of four 125-hp. scotch marine hand-fired boilers which used No. 3 nut coal by three 250-hp. water-tube boilers with air-cooled side walls and floor burning pulverized coal,—No. 5 carbon from southern Illinois, reduced the cost of steam to Jos. T. Ryerson Co. of Chicago from 80 cents per 1000 lb. to 46.5 cents. Return on the investment was 15 per cent a year.

Fusion Welding Requirements

Workmanship for Classes 1 and 2 for Unfired Pressure Vessels. By L. G. Haller

SINCE THERE SEEMS to be some confusion among engineers as to these differences, a table has been compiled to present ready comparison. As to difference in uses, Class 1 can be used on all classes of pressure vessels and, if *all seams* are X-rayed, fulfills the A.S.M.E. Boiler Code for fusion welding. Class 2 must *not* be used for vessels to contain lethal gases or liquids, for any liquids at 300 deg. F. or above, for pressures over 400 lb. per sq. in., for gases or vapors at temperatures over 700 deg. F., or for plate thickness, as required by permissible stress, over 1½ in. thick The pressure limitation does not apply, however, to vessels under hydraulic pressure at atmospheric temperature.

Detail of Fusion Welding Requirements

REQUIREMENT	CLASS 1	CLASS 2
X-rayed to prove Soundness of Welds	All longitudinal, one circular seam	None required
Welds Annealed to Relieve Stresses	Yes	Rarely
Plate Thickness	Unlimited	1½ in. Maximum
Allowed Efficiency of Weld	90 Per cent of solid plate	80 Per cent of solid plate
Qualifications of Welders and Check on Performance. See Note Below	Class 1 Required. Two coupons attached to shell plate being welded, one at each end of one longitudinal joint of each vessel. Continuous check.	Class 2 Required. Welder qualified by making one coupon every 6 mo. Check only at 6-mo. intervals
Bend Test	30 Per cent	Electric, 20% Oxyacetylene, 15%
Tensile Test of Joint	At least equal to minimum of the range of plate, on one coupon taken from every vessel	Equal to 95 per cent of minimum range of plate, on one test coupon once each 6 mo.
All-Weld-Metal Test	20 per cent elongation in 2 in.	None required
Weld-Metal-Density Test on Specific Gravity	Specific Gravity 7.80 minimum	None required
All-Weld-Metal Tensile Test for Plates ⅝ in. and Heavier	Equal to plate	None required

Note: The main difference between Classes 1 and 2 is the X-raying, annealing, and that Class 1 work is continuously checked on every job by physical tests of coupons attached to each vessel, while Class 2 work is checked only once every 6 mo. by requiring welders to make only one test coupon semi-annually.

This table gives a synopsis of requirements, for quick reference, the full details being given in the 1931 issue of the Code for Unfired Pressure Vessels, which can be obtained from Am. Soc. of Mech. Engrs., 29 W. 39th St., New York City.

According to the Journal of the Fuel Society of Japan a good deal of attention is just now being devoted to the question of economy in steam-operated electric power stations in that country. At the new plant of the Nippon Electric Power Co., pulverized fuel has been adopted for the firing of the boilers while at the new generating station in Tokio of the Japanese Imperial Railways the boilers have been adapted for both chain grate and pulverized fuel firing.

POWER PLANT ENGINEERING November 1932

Three Unit Drive Helps Heat Balance

Thilmany Pulp & Paper Co., Kaukauna, Wis., Uses a Westinghouse Turbine Drive with D.C. and A.C. Generator in Parallel with Utility System to Balance Steam and Power Demands

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POWER AND STEAM form a considerable part of the production cost of paper so that paper mill engineers have not been slow to take advantage of economies made possible by improvements in steam and electric equipment. These improvements have not always been widely accepted by the industry, however, leading to the occasional complaint that the industry as a whole has been slow to modernize.

Regardless of the truth of the charge many ingenious arrangements have been made in individual mills, one of the most recent being a three unit drive in the Thilmany Pulp & Paper Mill at Kaukauna, Wis. A 3600-r.p.m., 820-kw. turbine drives through a 3 to 1 double herringbone reduction gear, to a 320-kw., 250 v. d.c. generator and a 500-kw., 480 v., 3 ph., 60 cycle a.c. generator. The turbine is a combination impulse reaction machine with 2 rows of impulse and 16 pairs of reaction blades as shown by Fig. 2.

Steam is supplied to the turbine at 200 lb. abs., the steam flow being controlled by the oil governor so as to maintain a constant exhaust pressure of 40 lb. abs. This steam is used on the three paper machines No. 1 a 90-in. Yankee, No. 2 a 100-in. Yankee and No. 3 a 110-in. Fourdrinier in the pulp mill for process and for building heating. The amount of steam to the paper machine varies with the size speed and weight of paper. Requirements for heating steam depend, of course, upon the weather.

This installation was made to provide d.c. for the paper machine drives, generate power by the reduction of steam pressure from boiler to process pressures and at the same time establish a means of balancing the steam and power requirements so as to prevent waste of exhaust steam.

As shown by Fig. 1, Nos. 1 and 2 paper machines are supplied with d.c. direct from the d.c. generator. The connected load for each machine is 100 hp. The No. 3 machine requiring 250 hp. is driven with a direct connected back pressure turbine whose water rate is less than the machine's demand for drying steam, and make-up steam is supplied through regulating valves to the dryer header from the exhaust of the three unit set. The a.c. generator is connected to the main switchboard and is paralleled with the city electric system and the company's 3500 and 2000-kw. steam turbines.

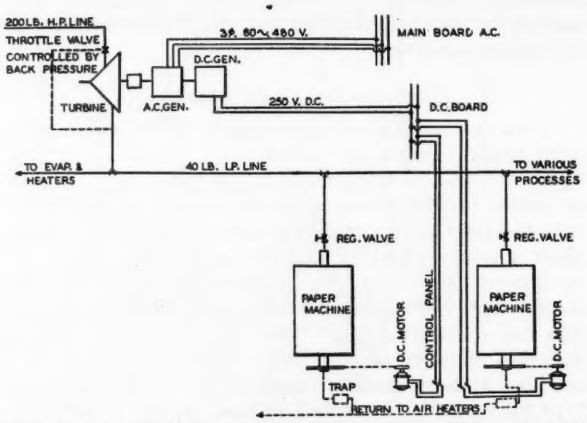


FIG. 1. DIAGRAM OF THREE UNIT DRIVE CONNECTIONS

When the low-pressure steam requirements are sufficient to produce exactly the amount of direct current being used, the a.c. generator floats on the line. If the steam requirements produce more power than is needed for d.c. generation, the a.c. generator takes up the extra capacity of the turbine and puts it on the regular a.c. bus. If the steam requirements are too low to meet the d.c. demand, the a.c. generator motorizes and helps drive the d.c. generator. At no time is there any excess low pressure steam produced because the pressure on the

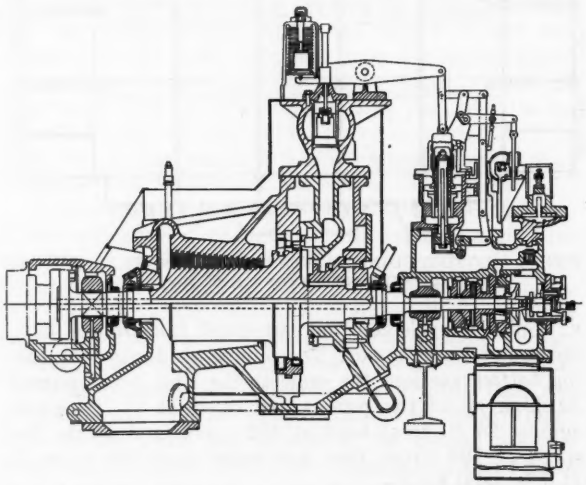


FIG. 2. CROSS SECTION OF THE WESTINGHOUSE TURBINE

low pressure line is maintained constant by the automatic regulating of the turbine through the back pressure control valve which operates the inlet valve allowing just sufficient steam to enter the turbine to satisfy the low pressure demand.

In addition to saving any steam that had previously been wasted, the a.c. generator has delivered as much as 500 kw. back into the system as byproduct energy.

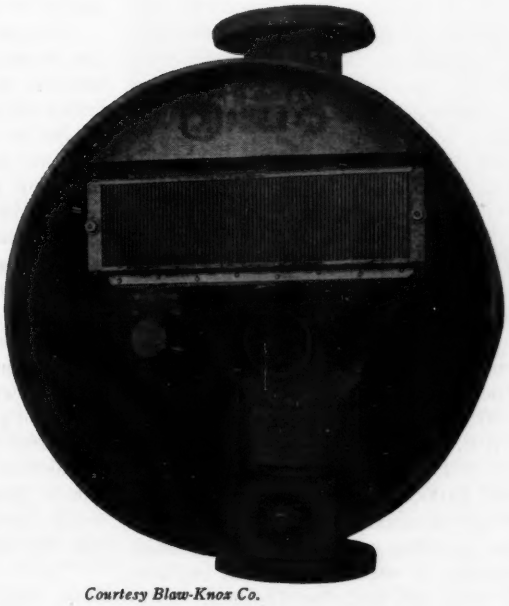
The arrangement, design and installation of the equipment was worked out by C. R. Seaborne, general superintendent of the Thilmany Pulp & Paper Co.

A NEW MACHINE for briquetting sawdust is said to turn out a product twice as heavy as wood and yielding as many heat units as a similar weight of coal.

Power Utilization

Steam Purifier Economies

By
REGINALD TRAUTSCHOLD



CENTRIFUGAL FORCE AND BAFFLING BY PLATES USED TO REMOVE MOISTURE AND DIRT FROM STEAM

Courtesy Blaw-Knox Co.

STEAM GENERATED in any active boiler is in intimate contact with the water and picks up minute particles of suspended liquid, the tendency to do so increasing with the rate at which the steam is liberated. The modern high-pressure plant driven at heavy ratings is more affected than those where steam is generated in a more leisurely fashion.

Besides reduction of the producing capacity of the steam generating unit, concentrates and impurities, soluble and in suspension, will contaminate the steam if there is any foaming or priming of the boiler. Water alone in the steam is bad for engines and turbines, eroding metal parts against which it impinges and washing oil from valves, cylinders and pistons. If scale, scum and sediment are also present, equipment deterioration is further intensified and passages become clogged.

By using pure water exclusively for boilers much of this trouble can be avoided, but not all, since the steam generated may not be dry, particularly if rates of generation are rapid and steam demands vary widely and rapidly. In many more instances, distilled water is not used but some process of water softening, and there are even numerous water supplies that are deemed satisfactory for boiler use with no treatment whatever.

Disregarding the damage, considerable as it may be, that may occur within the boiler in the absence of a softening process, substantially dry steam freed of moisture and entrained impurities may be secured inexpensively by installing suitable modern steam purifiers.

These devices may employ baffles, screens, grids or different arrangements of deflecting plates for removing the water and foreign matter from the steam, some using centrifugal force to aid in effecting the disassociation, since water and virtually all entrained impurities are readily removed by such action. Of the two general classes, internal units are placed within the steam drum of the boiler, while the external units may be located almost anywhere between the boiler and the equipment making use of the steam.

Purifiers in Superheat Plants

Even in plants generating superheated steam, substantial economies are realized by placing a steam purifier in advance of the superheater unit, as the superheater functions more efficiently if the entering steam is freed of virtually all entrained moisture; each 1 per cent of moisture extracted from the steam before it is subjected to superheating increases the elevation in its final temperature by about 16 deg. F. Also, drying and cleaning the steam before it enters the superheater protects the coil elements from becoming clogged or fouled.

Clean, dry steam for turbine use is of importance, as higher superheat secured by thoroughly drying the steam increases the turbine efficiency about 1 per cent for each increase of 11 or 12 per cent in steam superheat. With dry, pure steam, need of reblading is less frequent and increase in turbine water rate, from cutting and scoring of the turbine blades is avoided.

Savings Effected in One Plant

Cash savings secured at the plant of the American Box Board Co., Grand Rapids, Mich., are to the point, although not so marked as those secured in other in-

stances that could be cited. At this particular plant, however, records of improvement and how it was secured have been maintained.

River water supply, passes through filter beds and is treated with lime and soda ash before it enters the boilers but, despite these precautions, it contains as used an average of about 2½ gr. of hardness per gallon. Before the steam purifiers were installed, the boilers were operated at 190 lb. pressure at an average load of about 150 per cent of rating, the exhaust from the several turbines and reciprocating engines being used for heating and drying processes in the mill. Considerable trouble was experienced with scale and from water carried over into the turbines.

Three main turbines had to be taken down for cleaning at least six times a year, water rate showing marked increase as the turbines accumulated dirt. Each cleaning required the services of half a dozen men for 12 hr., an average expense for labor of $907.20 annually.

Since the steam purifiers have been installed, furnishing dry, clean steam, bi-yearly turbine inspections have sufficed, saving a yearly outlay of $756, the thorough boiler inspections made each 6 mo. costing about $75 each. Furthermore, drying of the steam before it enters the steam superheaters has increased the superheat of 57 deg. to 80 deg., an increase in final steam temperature of 23 deg.; this improvement results in saving approximately 304 t. of coal annually, based on yearly consumption of 15,000 t., or cash saving of $1500.

Besides these obvious economies, effected by installation of three steam purifier units costing installed $2300, necessary cleaning of superheaters and replacement of superheater tubes has been less frequent, while savings attributable to more dependable and continuous operation of the power plant are a matter of consequence. Also, an element of insurance and protection against breakdowns has been introduced, lubricant saved, valves are tighter and packings last longer.

Cleaning and Lubricant Savings

That savings in cleaning expenses and lubricant costs are decidedly worthwhile is indicated at the Page Steel & Wire Co., Monessen, Pa. Lubricant consumption was reduced 10 gal. a day as a result of installing steam purifiers, reducing the yearly bill for cylinder oil by $1300. Incidentally, a saving of like amount is realized in this same plant by reason of the increase in superheat made possible by the thorough drying of the steam before it enters the superheater coils. These two items, totaling $2600 are attributed to the steam purifier installation that cost a total of $1868.

At the Transue & Williams Steel Forging Corp., Alliance, Ohio, installation of steam purifiers has resulted in the yearly savings of $655.20 in labor costs for cleaning and repairing the superheater, of 200 or more new superheater tubes costing about $1000, and fuel saving in normal years of $2250 due to increase of 60 deg. in steam superheat. Operating cost, carrying charges and upkeep expenses of these steam purifiers is reported less than $410 a year, giving net cash saving as about $3500 annually, at an investment of less than $2000.

Drying Efficiency

In a relatively new paper mill plant on the Schuylkill River near Philadelphia, the river water, heavily contaminated with coal dust and other impurities, is treated by a combination chemical process to minimize scale formation in a battery of boilers aggregating 1500 hp. rated capacity and called upon to deliver a maximum of 60,000 lb. of steam per hour.

Due to the method employed of conditioning this fouled river water for boiler use and because of rather excessive and unavoidable variations in the water levels in the boilers, considerable foaming and priming occurs at times. This gave trouble from wet steam in the engine cylinders and rapid accumulation of dirt on the blades of the steam turbine units.

Because of a somewhat unusual arrangement of piping, steam from all the boilers is collected into one large, common steam main, making it possible to pass the entire steam supply through one steam purifier.

Before the installation of this steam separator, the moisture content of the steam averaged close to 1.6 per cent and not infrequently went to well over 3½ per cent. Since the purifier has been in service, average moisture content of the steam has been less than 0.04 per cent, often too small to be accurately determined.

Thoroughness of removal of dirt from the steam is evidenced by the appearances of samples of boiler blowdown water, trap discharge, and condensate from a sampling pipe in the discharge from the steam purifier. The concentrated boiler water and the trap discharge from the purifier are almost black due to the presence of coal dust carried in suspension, while the condensed steam from the purifier is crystal clear. Chemical analysis of these three water samples showed that the boiler water contained 18 gr. of sodium chloride per gallon, the trap discharge 8 gr. and the condensate only a trace.

Sixty Per Cent Return on Investment

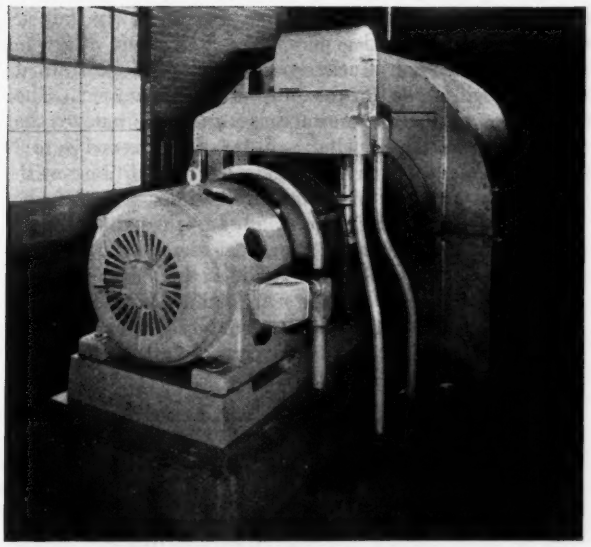
As to yearly return on the dollar invested, the records cited for the American Box Board Co., the wire mill and the forge plant furnish some statistics of this nature but, lest they be looked upon as rather extreme cases, the average yearly yield per dollar invested as reported by a larger and more varied list of steam purifier users, including seven representative central stations, (two of which are gas companies) four paper mills and six industrial plants, the latter including manufacturers, oil refiners and establishments working in steel, show savings from these seventeen plants aggregating close to $100,000, to the credit of steam purifiers costing installed about $60,000. In other words, this particular group of plants has found that $1 invested in steam drying and cleaning devices has brought back yearly an average of $1.60. In a number of cases, the yield has been several times as much and in only one case has the rate of return been less than 45 per cent annually. This sole exception, incidentally, is a central station where the yield, while not startling, was about double the rate of return permitted under public service commission regulation for public utility investment.

Whether the yield is 50 or 100 per cent, or several times as great, an investment netting even the minimum returns is highly desirable and profitable even when industry is suffering severe depression and money is scarce. No matter what treatment may be required to condition the water supply for boiler use, or when the water supply is of a quality that makes chemical treatment unnecessary, the installation of steam purifiers or separators, if they are of the right size, correctly located in the proper place and suitable drained, would seem to pay handsomely.

Hydraulic Coupling Speed Control

By G. C. POLK

Accurate Speed Regulation Over Wide Range. Using Constant-Speed Motors.



Installation in Ohio River Station, Southern Indiana Gas & Elec. Co.

MANY DEFINITE advantages accrue to the use of the simple squirrel-cage motor in industrial plants and power houses, such as across the line starting, simplicity and robustness. Unfortunately, its speed is constant. Even if a two or three-speed motor of the multi-winding type is used, the several speeds are fixed and are often awkwardly spaced, which unfits the motor for drive where considerable accurately-controlled speed variation is necessary.

Practical advantages of the motor are such that it is widely used in conjunction with accessory drive as for fans, with dampers to control the output of the fan at constant speed, although dampered control is wasteful in power and the fan is subjected to unnecessarily heavy erosion when handling dust-laden gases at loads calling for a partial closing of the dampers. Since draft fans must be of sufficient size and speed to handle maximum requirements, some method must be employed to reduce their output under normal operating conditions and to vary output over considerable range for changes in boiler load.

Principle of Action

Development of a hydraulic coupling for speed control has eliminated the constant-speed disadvantage of squirrel-cage motor application and a large number of installations in Europe are giving satisfactory service. The coupling gives an infinite number of speeds, from a constant motor speed ranging from nearly full motor speed to about 20 per cent of that speed. The motor to be started under practically no load; for fans the wheel is protected against rapid acceleration strains when the motor is thrown directly across the line. Characteristics of the coupling are well suited to controlling machines where the power varies even as greatly as the cube of the speed.

This coupling has been introduced in the United States and Canada by Hydraulic Couplings, Inc., and sold by American Blower Corp. While comparatively new in this country, its field of use in Europe has interested American engineers. An installation at the Lister Drive station of the Liverpool Corporation, totaling approximately 350 h.p., as an example, showed a power saving varying from 20 to 75 per cent depending on the boiler load compared to the damper control system previously employed, with substantial saving in maintenance due to less wear and tear on the fan.

Construction and Action

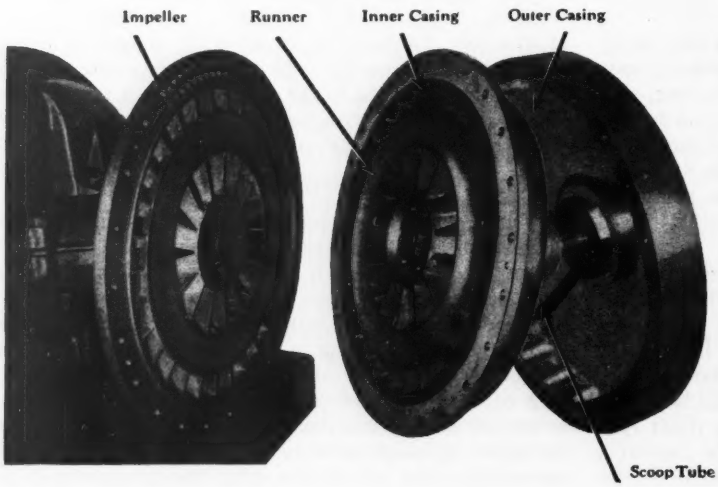
Three essential elements are used: an impeller on the driving shaft; a runner on the driven shaft, as shown in Figs. 2 and 3; a quantity of oil as working fluid, occupying the space indicated in the runner and impeller by arrows showing the direction of the flow of oil when the coupling is in operation. The oil cavity formed by the runner and impeller is a circular vortex ring of oval cored cross-section. The runner and impeller are similar and both have plain radial vanes in the oil cavity which serve to sectionalize the oil ring and ensure that the oil rotates with the runner and impeller. Relative to the coupling, then, the only movement of the oil within it is around the circular core formed by the two members at the center of the oil cavity. The runner and impeller have a distance of from ½ to ¼ in. between them, the impeller always running faster than the runner. Maximum speed of the runner will be from 1½ to 3 per cent below that of the impeller, this small difference causing a difference in centrifugal force in the two elements to set up a flow of fluid from the impeller into the runner in the outer diameter of the vortex ring and back into the impeller at the smaller diameter of this ring.

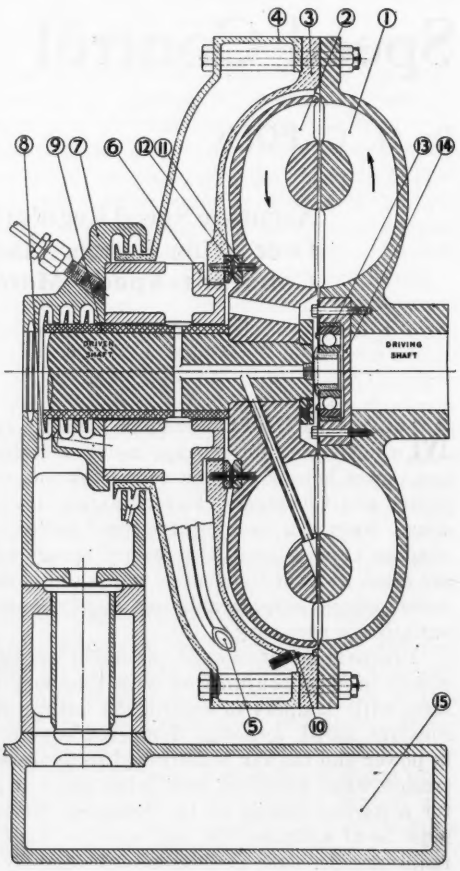
Not only does this ring of fluid rotate as a whole about the coupling axis but it turns about its own core, the fluid flowing outward in the impeller and inward in the runner. In passing outward, the particles of fluid held in the compartments of the impeller are carried around the coupling at a uniform angular velocity. Their linear velocity increases, however, because they move outward to revolve in circles of increasing radii. Thus they are forced to take up fresh momentum and kinetic energy in the impeller, and it is their reaction to this, felt as a pressure on the vanes of the impeller, which constitutes the torque load on the driving motor.

As they pass inwards in the uniformly-rotating runner, the fluid particles must give up the newly gained momentum and kinetic energy and it is their effort to preserve a constant linear speed as they move inward which provides the torque output of the runner. The torque output of the runner is exactly equal to the torque input to the impeller and the slip is from 1½ to 3 per cent depending on load and speed conditions, with a coupling full of working fluid. This slip can be increased any desired amount up to approximately 80 per cent by withdrawing a part of the fluid from the coupling, which has the effect of increasing the core size of the vortex ring, making it possible to control the speed of the runner from approximately 20 per cent full speed up to within 1½ to 3 per cent of full motor speed.

FIG. 1. BELOW: DISASSEMBLED VIEW OF HYDRAULIC COUPLING

FIG. 2. AT RIGHT. SECTIONAL VIEW OF COUPLING. 1, IMPELLER; 2, RUNNER; 3, 4, INNER AND OUTER CASINGS; 5, 6, SCOOP TUBE HOUSING; 7, 8, MANIFOLD, TOP AND BOTTOM HALVES; 9, SHAFT SLEEVE; 10, LEAK-OFF PORTS; 11, 12, THRUST RING RUNNER AND INNER CASING; 13, BALL THRUST BEARING; 14, IMPELLER PLUG





In order to effect this withdrawal while the coupling is in operation a scoop tube is provided, as shown in the sectional view, Fig. 2.

Performance

Figure 3 shows the relation between volume of fluid in the coupling, which is proportional to driven speed, and per cent of kilowatt input of the driving motor; A for one-speed and B for two-speed motors.

Floating on extensions of the driven and motor shafts, as indicated in Fig. 2, there are no bearings in the coupling except a ball thrust bearing located between the runner and the rotating casing, whose purpose is to hold the runner and impeller in proper relative positions. Normally there is little for these thrust bearings to do and they are located between parts usually operating at low speeds relative to each other. The connection between stationary parts and the coupling is through labyrinth joints with from 1/32 to 1/16-in. clearance.

Oil between the inner casing and the impeller is thrown off into the outer casing through calibrated leak-off nozzles (10) and is held at the outer periphery of this space by centrifugal force. As oil in this space increases, it is picked up by the stationary scoop tube (5) and carried into the housing (6), which is divided into two cavities, one into which the scoop tube discharges and the other which carries oil back into the oil space within the impeller and runner sections through cored holes, one of which is indicated in Fig. 2. The cored section of the scoop tube housing to which the scoop tube connects is also connected with an external pipe to the upper tank, Fig. 4, oil picked up by the scoop passing into the scoop tube housing and from there into the upper tank. From the upper tank the oil flows over an adjustable weir through a pipe connecting with the second cored cavity in the scoop tube housing, thence through the cored holes previously mentioned, back into the working elements of the coupling.

Since the scoop tube carries off the oil as fast as it passes the leak-off nozzles, response to a movement of the weir is immediate. When the weir in the upper tank is all the way down, no oil remains in the upper tank and therefore the coupling remains full, all oil pumped to the upper tank through the scoop tube flowing back into the coupling over the low weir immediately. As the weir is raised, more and more of the oil supply remains in the upper tank, less and less oil returning to the coupling. When the weir is at its highest position, the coupling is completely emptied. With the coupling full of oil, the runner runs at maximum speed. When the coupling is entirely empty, the runner runs at its lowest

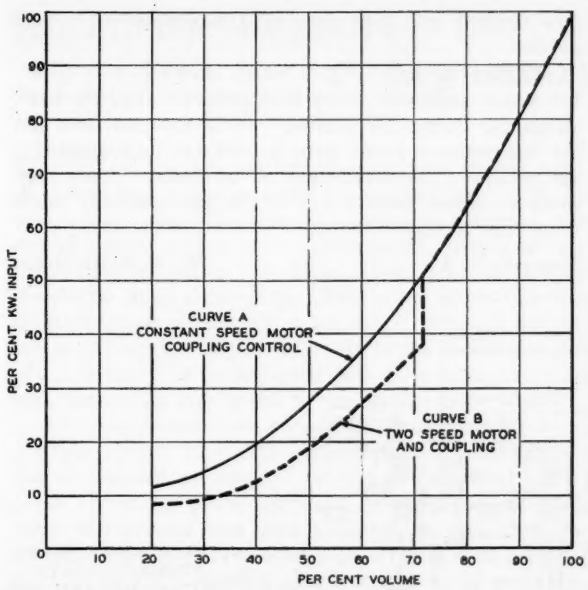
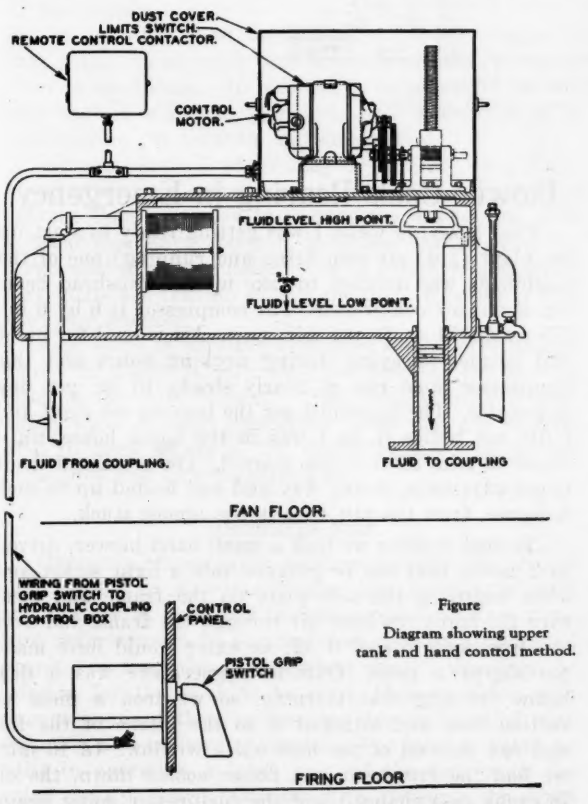


FIG. 3. RELATION OF VOLUME OF COUPLING FLUID OR SPEED TO MOTOR INPUT

speed, but windage between the runner and impeller when all oil is removed causes some rotation of the runner on fan drive as at the lowest speed the power required to drive a fan is almost nothing.

Weir height is set by means of a screw shaft functioning through a worm-driven nut, the worm being driven by hand or motor. Automatic remote control of pneumatic, hydraulic or electric type may be used.



Figure

Diagram showing upper tank and hand control method.

FIG. 4. CONNECTIONS TO UPPER TANK AND CONTROL OF ITS OIL LEVEL

In the coupling subbase is located a sump tank to receive any drainage oil from the oil throwers on the labyrinth joints and to hold the contents of the coupling should it be shut down for any reason when full of oil. A small take-off pipe from the coupling discharge to the upper tank by-passes a small amount of oil through an ejecter connected to the sump tank, which keeps the sump tank empty during operation. If the coupling is stopped when full and part of the oil in the coupling drains into the sump tank, sufficient oil is left in the coupling to operate the ejector and quickly bring all of the oil back into the operating circuit. The tubular weir works in a long sleeve with a good fit and is also provided with piston rings to take up any possible wear at this point.

Trap Problem

FOR A water-heating job with automatic temperature regulator a trap is to remove condensation. The heating element is to heat 2800 gal. per hr. from 40 deg. to 180 deg. with steam at 100 lb., condensing 3700 lb. per hr. It will also heat 1000 gal. per hr. from 40 deg. to 180 deg. with steam at atmospheric pressure, condensing 1200 lb. per hr. The question is, what size trap to use to handle condensation at maximum and minimum pressures?

T. H. Rea of Armstrong Machine Works furnishes the following solution to the problem.

With steam being supplied at zero gage pressure part of the time, it will be necessary to install the trap far enough below the heater to obtain a static head that will force water through the trap. In this case, we recommend approximately a 5 ft. drop to give a net differential of about 2 lb. At 2 lb. pressure differential, a ½-in. orifice will pass in excess of 2600 lb. of condensate per hour which gives a factor of safety a little greater than two to one for handling the 1200 lb. of steam that would be condensed at zero pressure.

At the same time, the trap must be large enough to open the ½-in. orifice at the maximum or 100 lb. pressure and in this case it works out that a 2-in. trap is required as the ½-in. orifice cannot be used in any smaller sized trap.

This problem is somewhat more complicated than merely selecting the proper size of orifice as care must be taken that there is good gravity drainage from the trap to the boiler room or to suitable apparatus for pumping the condensate back to the boiler room. The line must be of ample size to prevent any appreciable back pressure because if the back pressure is high enough to reduce the capacity below 1200 lb. per hour, water will accumulate in the heater and damage will result on account of water hammer.

SOME IDEA of the power used in steel mills is gained from the new equipment in the South Works of the Illinois Steel Co. The new beam mill which rolls heavy H sections for columns from 20-t. ingots has a 5,000-hp. reversing motor driven from motor-generator sets with extra heavy flywheels to steady demand on the system. The roughing stand has a 7000-hp. d.c. motor, the intermediate mill a 6000-hp. and a 2000-hp. and the finishing mill a 3000-hp. Besides this total of 23,000 hp. in the main motors, some 350 other motors for auxiliary services are used in the mill.

Water Heater Connections

FOR THE BENEFIT of power plant engineers who would like to know definitely how to hook up for producing hot water and how to keep the water hot for various purposes, are submitted herewith five self-explanatory sketches which completely show and describe the proper piping arrangement.

Figure 1 shows how to pipe up a hot water storage tank, using a hot water temperature regulator and a steam control valve. The regulator is hydraulically operated. Simply connect to your service water system at the point marked "⅜ in. water pressure supply to regulator." When the temperature of the water reaches the desired point, the metallic expansion tube, which is inserted into the tank, expands and permits the water pressure to pass through the regulator to the diaphragm valve and shuts off the steam. When the temperature decreases, the tube will contract, thereby discharging the pressure from the diaphragm valve and turning on the steam.

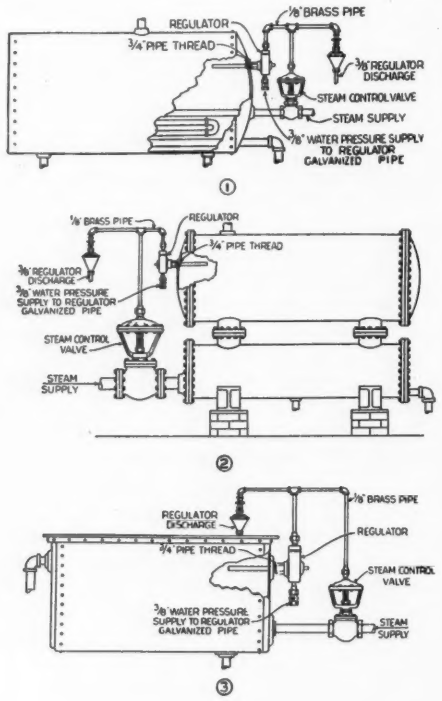
With a control system of this kind the control valve stays wide open until the desired temperature is reached and then closes completely. In other words, there is no "wire drawing." This type regulator will operate the largest steam or other control valve, at any pressure, with as little as 2 deg. variation in temperature and is easily adjusted to act at any temperature up to 300 deg. F.

Figure 2 shows how to pipe a hot water heater and storage tank, the operation being the same as in Fig. 1, while Fig. 3 is for an open tank, piping arrangement for Figs. 1, 2, and 3 being much the same.

For a slightly more complex problem, Fig. 4 shows two hot water generators, both control valves being operated by one hot water regulator. An extension of this method will take care of any number of control valves.

Finally we have Fig. 5 which shows how to pipe a hot water generator using high-pressure supplementary steam for doing the heating. It is assumed here that the low-pressure steam supply need not be regulated at all because it is insufficient in quantity. Some high-pressure steam must therefore be automatically added from time to time.

Newark, N. J. W. F. SCHAPHORST.



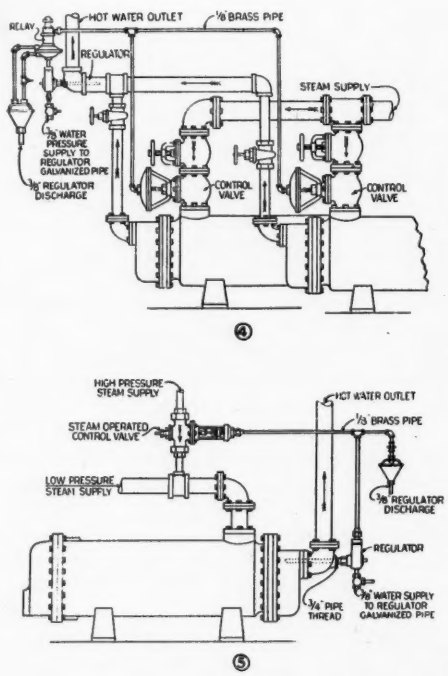


FIG. 1. HOT WATER STORAGE HEATER
FIG. 2. HEATER AND STORAGE TANK
FIG. 3. HEATER FOR OPEN TANK
FIG. 4. CONTROL FOR TWO HEATERS
FIG. 5. HIGH-PRESSURE STEAM CONTROL

Blower Cools Bearing in Emergency

THIS MORNING while I was getting ready to start up the plant (I do my own firing and running) one of the machinists was detailed to take up the crosshead bearing of our air compressor. The compressor is 6 by 6 in., 275 r.p.m., 54 cu. ft. per min. unit. Air is used for paint and lacquer spraying during working hours and this compressor must run as nearly steady 10 hr. per day as possible. The machinist got the bearing too tight and I did not notice it, as I was in the boiler house, until about 30 min. after it was started. The crosshead itself is not adjustable in any way and had heated up to such a degree, from the pin, that it was almost stuck.

To cool it down we took a small hand blower, driven by a motor that can be plugged into a light socket and after removing the side plate on the frame and hood over the crank, we blew air through the frame and over the crosshead to cool it off, as water would have made too sloppy a mess. Outside temperature was 4 deg. below freezing that morning, so we took a piece of suction hose and attached it to the intake of the fan and ran the end of the hose out a window. In 10 min. we had the crosshead and frame cooled down, the oil in crank case changed and the compressor going again.

Minneapolis, Minn. FRED S. RUTLEDGE.

Automatic Pressure Regulation

By K. B. Howell*

PERHAPS it was natural that early automatic regulators had rather complicated mechanisms. Step by step trains, where one impulse produces a second, the second a third and so on to a final result, have a certain fascination and grip the imagination even if lacking something in practicability. But, since industries and utilities which pioneered in automatic pressure regulaton have been led largely to revert to the simplest methods possible, it is to be hoped that those now adopting such regulation may profit by the earlier experiences.

No complicated train of mechanism is justified when a single simple step will accomplish the same object. Lag or lessened sensitivity, liability of failure of multiplied operating parts, difficulty of synchronizing all steps and greater cost and attention for maintenance are disadvantages of the complicated train. Best achievement in design is typified by the maximum of accuracy, dependability and simplicity which will give the desired result.

Fundamental Requirements

Accuracy requires good workmanship. Exactness of action has sometimes been achieved by elaboration involving pilot valves and auxiliary motors but often at the expense of reliability. Friction, sticking, clogging, binding, leakage, weakening of springs are some of the obstacles encountered. Auxiliary mediums such as air, water or electricity introduce a possibility of failure of the supply.

On the other hand, equipment may be so cheapened that it fails in accuracy and in quick response to variations in conditions. In between is to be sought the design that is sound in principle, well made, simple in construction yet accurate and dependable.

While unlimited power may be obtained in a pneumatic or hydraulic motor to move a valve, any greater amount than necessary to operate the mechanism, with a reasonable safety reserve, is useless and is never incorporated in the regulator. Use of cylinders and levers may introduce friction so that the gain in power is considerably lessened.

Large steps in pressure reduction should give no difficulty if design is such that the force of the flowing fluid on the valve is small. High fluid velocity is commonly used in small regulating valves and can be handled in large valves if the design is based on proper principles and experimental data.

Regulator Size

Obviously, there is no relation between the size of pipe needed to maintain proper line velocity of fluid and the size of regulator to reduce pressure, since pressure reduction can be accomplished only by a restricted opening in the valve. Regulators should, therefore, be selected for the work to be done, then be fitted with flanges to adapt them to the pipe line or installed with reducing and increasing nozzles. Too large a valve results in operation a large part of the time with the valve nearly closed, causing wire drawing, impaired regulation and cutting of seats which calls for increased maintenance.

Dead-End Service

For conditions where the demand on the low-pressure side falls at times to practically zero, unless the valve will shut off tight, pressure will build up on the low side by leakage and destroy regulation. Even with the seated type as required for complete shut off, wire drawing may cause leakage after a time, also unbalanced disc areas may cause deficient regulation where fluctuation in the high pressure is considerable.

In some cases, the complete shut off is required but often a balanced type regulator with hand shut-off on the high-pressure side or a relief valve on the low-pressure will take care of light load requirements.

In pressure regulation, the fundamentals to be kept in mind are: To select the simplest type of valve that will ensure the desired result; to make sure of best quality of materials and workmanship; to choose the size and design best suited to meet requirements; to install so that proper inspection and care can be readily given. With these fundamental requirements met, automatic control will be accurate, dependable and safe.

*Mercon Regulator Co.

Painting Steel Work

All steel work should be protected against rust and corrosion by suitable and adequate paint, properly applied. The first or priming coat is of the utmost importance and should be intended primarily to retard corrosion. Red lead and oil makes an excellent hard, dense and elastic paint for this purpose but is quite expensive and iron oxide which has high protective properties is often used because of its low cost. About 10 per cent of zinc chromate added to the latter increases its rust inhibiting properties.

The finish coat depends upon the location and the service. For light interiors a white or gray mill paint is excellent, two coats of white or one coat of gray being necessary over the red. Where dark colors are desired a black graphite paint is good, or for outdoor service an aluminum paint, mixed with a little linseed oil to increase its elasticity, if temperature changes are sufficient to cause expansion.

New galvanized sheets take paint badly until weathered some. They can be prepared for painting, however, by washing with copper sulphate. After the sheets are dry, the crystals should be brushed off before the paint is applied.

Entire cost of painting is seldom over 2 or 3 per cent of the cost of a building and less than that for a piece of equipment. Of this from 60 to 75 per cent is in labor so that little is to be saved by using inferior paints. Poor paint means early repainting and the additional cost of labor more than uses up the saving that can be made on paint. Paint failures are the result of a good paint used in the wrong location, inferior paint, improper application or improper preparation of the surface.

P. F. Rogers.

Steel straps for tension members, channels or sections for compression members, weld the entire structure; thus Westinghouse announces a roof truss of simple, easy construction, one-third lighter than former trusses, without sacrifice of strength.

POWER PLANT ENGINEERING November 1932

High Suction Pressure *in the* ICE PLANT And How to Maintain It

By
M. F. Knoy

OPERATORS OF ice plants hear from time to time reasons why suction pressures should be maintained as high as possible, but judging from the way this item is neglected in some plants, all engineers have not been properly impressed by the benefits to be derived. These benefits, both direct and indirect, constitute a worthwhile saving that should be taken advantage of whenever possible.

In connection with a high suction pressure, the first advantage is the reduction in the amount of power required by the compressor. Perhaps no engineer will dispute the fact that the energy requirements decrease as the suction pressure is raised, but many fail to realize how rapid this decrease is. The graph, Fig. 1, shows that, assuming the head pressure to remain constant at 151.7 lb. gage (corresponding to a condensing temperature of 85 deg. F.), raising the suction pressure from 10 to 25 lb. gage decreases the theoretical indicated horsepower per ton of refrigeration from 1.2 to 0.86. This represents a theoretical saving in compressor power of approximately 28 per cent. Actually the saving would be greater than this, due to a greater volumetric efficiency of the compressor at the higher suction pressure. Figure 2 shows how, neglecting the effects of clearance, the volumetric efficiency improves with increasing suction pressure. From this graph we see that the volumetric efficiency is 81 per cent at the 10-lb. suction and 85 per cent at the 25-lb. suction. When we consider the combined effects of theoretical indicated horsepower and volumetric efficiency we find that the power requirements at the higher suction pressure will be reduced by approximately 33 per cent.

Of course the exact power saving to be realized from increasing the suction pressure will depend to some extent upon the head pressure being carried, being greater for the higher head pressures. The benefit in this respect will, however, be substantial for any ordinary operating conditions.

Less Lubrication Troubles

When speaking of lubrication troubles here we refer to all trouble in the plant due directly or indirectly to the action of the lubricating oil. Such troubles include not only the poorer lubrication obtained at low suction pressures but also the increased tendency on the part of the oil to breakdown and vaporize. This tendency is due to the higher temperatures prevailing in the compressor cylinder and to the fact that high temperatures affect the lubricating oil in various undesirable ways. In the first place too much heat will cause the oil to vaporize and go over into the ammonia system where it hinders heat transfer by fouling vital heat transfer surfaces in the condenser or the evaporator. In the next place, the heat may actually decompose the oil into carbon and permanent gases. The latter upon reaching the condenser may prove noncondensable, in which case they will cause an undue increase in the head pressure. Carbon remaining in the cylinder and valves of the compressor interferes with proper operation and may start serious leakage.

Figure 3 shows how compressor discharge temperatures are affected by the suction pressure, the head pressure remaining constant. Values for this graph were calculated from the Mollier chart and are based upon a condensing temperature of 85 deg. F. A brief study of this chart is sufficient to convince one of the advisability of keeping the suction pressure as high as possible when he remembers the adverse effects of high temperatures on the lubricating oil. In addition to less trouble from oil fouling a worthwhile economy will be realized in the reduced consumption of oil.

At the higher discharge temperatures shown by Figure 3 to accompany the lower suction pressures there is a distinct tendency on the part of the ammonia to dissociate into nitrogen and hydrogen, its constituent gases. Once these gases are separated they refuse either to combine again or to condense. They remain in the condenser and the receiver as non-condensable gases which, in accordance with the well known law of partial pressures, cause an increase in the head pressure. The increased head pressure not only causes more power consumption by the compressor but still further increases discharge temperatures, which in turn promotes more decomposition of ammonia. This vicious circle can be broken only by purging the condenser of the foul gases. In this purging, by whatever means, some additional ammonia will inevitably be wasted. This in addition to that decomposed may constitute an appreciable item in operating costs.

Having mentioned briefly some of the advantages of an increased suction pressure we shall, in order to make the discussion of practical value, outline some of the

steps that may be taken in the average ice plant to achieve this result. These are not presented in the order of relative importance nor is the list exhaustive, however, if the measures recommended are strictly applied at least some of the above named benefits will be realized.

All of the heat removed from the can water plus that entering the brine tank from its surroundings must eventually find its way into the ammonia through the evaporator surfaces. In order for this heat transfer to take place it is necessary for the ammonia within the evaporator to be colder than the brine without. In the average plant this so-called temperature split will be somewhere about 5 or 10 deg. F. The greater the split the colder the ammonia must be to hold the brine at a given temperature. This colder ammonia of course means a lower suction pressure. Anything that can be done to reduce the temperature split results in a corresponding increase in suction pressure.

In the first place a suitable oil should be used in the compressor and then every means should be employed to keep the operating pressures such as will not produce excessively high discharge temperatures with consequent decomposition and vaporization of the oil. As an added precaution the oil trap in the compressor discharge line should be drained periodically. If an abundance of oil is found here the liquid receiver should be tested for oil in the bottom, the necessary precautions being observed to prevent the sudden release of a dangerous quantity of liquid ammonia. These measures will go a long way toward preventing the evaporator from becoming fouled with oil.

To make sure, however, that it is kept free from oil, the evaporator itself should be tested at least once yearly through a drain line connected to its lowest point. Any oil found should be removed at once. After years of fouling the inner surface of the evaporator may have a

FIG. 3. LOW SUCTION PRESSURES MEAN HIGH DISCHARGE COMPRESSOR TEMPERATURES

FIG. 2. VOLUMETRIC EFFICIENCY OF THE COMPRESSOR IS HIGHER AT HIGH SUCTION PRESSURES

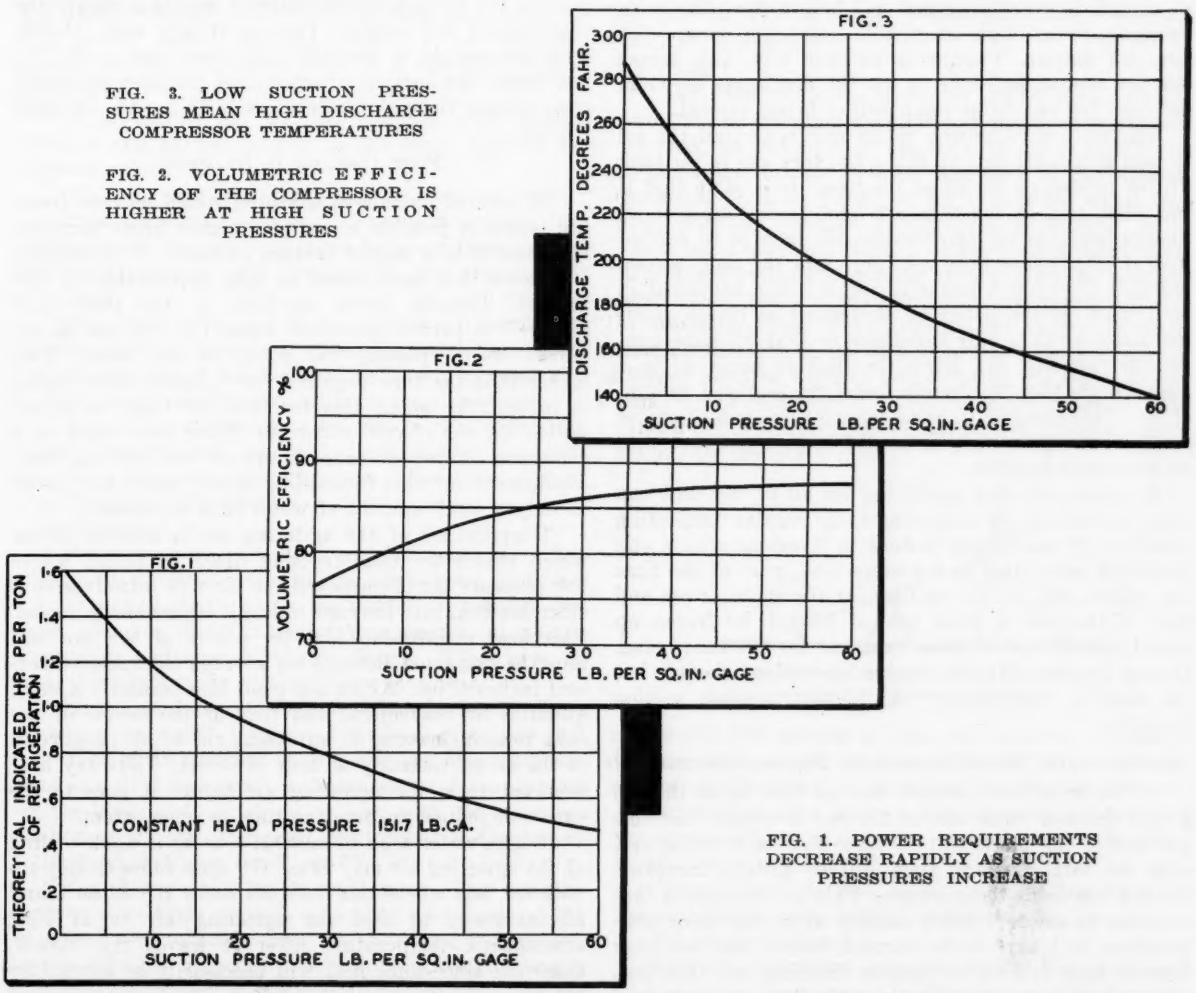


FIG. 1. POWER REQUIREMENTS DECREASE RAPIDLY AS SUCTION PRESSURES INCREASE

One of the greatest factors in keeping the temperature split at a minimum is clean evaporator surfaces. Evaporators do not, as a rule, become greatly fouled on the brine side. But very often oil from the compressor may find its way into the ammonia system as pointed out above. If present in the evaporator it acts as a heat insulator and makes necessary an increased temperature split. The thing to do, therefore, is to prevent oil reaching the evaporator if possible.

coat of sludge or semi-solid oil in which case the draining out of the fluid oil may only partially remedy the trouble. If in this condition, the evaporator should be removed from service during the slack season and thoroughly blown out with steam.

One other factor that reduces the temperature split by facilitating the heat transfer from brine to ammonia is a rapid brine circulation. In order that the proper circulation may be maintained at all times it will be

necessary for the agitators, bulkheads and similar parts to have periodic inspection followed by repairs when needed.

Another factor tending to reduce the temperature split in the evaporator is an ample supply of liquid ammonia at all times. It has been found that heat transfer is much more rapid in an evaporator flooded with liquid on the inside than in one filled with vapor, even though the same temperatures may prevail in both cases. All evaporators, unfortunately, are not designed for full flooded operation, but whatever the design being used it should be operated as nearly flooded as is possible without getting liquid ammonia into the suction gas.

Keep Every Ice Can Working

Even though the temperature split is kept at a minimum the suction pressure will be lower the lower the brine temperature is carried. It is evident therefore that we should do everything that will help to keep the brine temperature as high as possible and yet secure the required output. Putting it another way, this means that we should endeavor to get the maximum ice from the tank for any brine temperature being carried.

The most obvious way to do this is to pull the ice as soon as it is frozen. In this way every can in the tank will be producing ice all of the time. It is plain that if one-third, say, of the cans are kept frozen hard at all times a lower brine temperature will have to be carried than if all the cans were working all of the time, assuming that the same amount of ice is being harvested in both cases. If the policy of harvesting as frozen yields too much ice it is only necessary to shut off some compressor capacity and allow the tank to come up to a temperature that will barely freeze the required amount of ice. This increase in brine temperature will of course mean a correspondingly increased suction pressure with its attendant benefits.

Keeping each can producing ice all of the time can best be realized by adhering to a regular harvesting schedule. If harvesting is done in irregular spurts and dozens of cans filled at the same time, part of the time the pullers will be idle waiting for the ice to freeze and part of the time a great deal of ice will be frozen up ahead and the use of these cans lost for the time being. It may be seen that the regular harvesting schedule has its place in maintaining the highest possible suction pressure.

Maintain the Brine Level and Proper Circulation

If the brine level outside the can falls below the top of the finished block within the can it means that this portion of the block will be very slow in freezing and that the total freezing time will be greatly increased for a given brine temperature. This in turn means that in order to secure a given amount of ice the brine temperature will have to be carried lower. On the other hand a high brine level hastens freezing and thus permits a maximum of ice for a given brine temperature and a maximum brine temperature for a given amount of ice, other things being equal. Thus if the suction pressure is to be maintained at the highest possible value the engineer must not overlook the necessity of keeping the brine level as high as the design of the tank and the cans will permit.

Lively and uniform brine circulation among the cans should likewise be maintained. If broken baffles or faulty agitation permits the brine to remain more or less stagnant in portions of the tank the brine temperature in these sections will average higher than in the remainder of the tank and the ice made in these portions will be correspondingly less than their share. In order to keep up the output from the tank it will therefore be necessary to lower the average brine temperature of the whole and thus suffer the ills attendant upon a reduced suction pressure. We thus see that brine circulation is another factor that must not be overlooked.

Anyone who has made the test knows that the overweight ice block requires longer to free than does the block of normal size. This is perhaps due mainly to the tendency of the longer block to protrude up above the brine level where the heat transfer is comparatively slow. Hence if a careless ice puller habitually fills the cans fuller than necessary a lower brine temperature will be required to produce a given number of blocks. Many companies purposely make an overweight block to compensate for meltage before delivery and thus assure the consumer of full weight. That is all very well. Decide what overweight is desirable and then stick to it. Do not lower the suction pressure and increase operating costs merely through carelessness in filling the ice cans too full.

Fore Cooling Is Helpful

As pointed out above anything which hastens freezing makes it possible to carry a higher brine temperature and thus a higher suction pressure. Fore cooling core water has been found to help appreciably in this respect. Usually about one-fifth of the total heat required to turn a pound of water into ice can be removed before placing the water in the cores. This means that the time required for freezing after coring is reduced by about this fraction. If large cores are pulled the use of cold water for filling may result in a reduction of two or more hours in the freezing time. Equipment for this forecooling is not bulky nor costly as only a small amount of water is to be cooled.

Temperature of the agitating air is another factor which affects the total freezing time. In plants where low pressure air is employed the air will introduce considerable heat into the cans unless it is previously cooled. This heat is introduced at the center of the can and must be extracted through an average thickness of several inches of ice. As ice is a good heat insulator a small quantity of heat introduced thus at the center of the cans retards freezing to an extent out of all proportion to the actual quantity of heat involved. Thus any heat removed from the agitating air before it goes to the cans will reduce the freezing time to some extent.

Where water high in mineral content is used, cooling of the agitating air may cause the drop tubes to stop up with ice, but where this does not occur it will be found advantageous to cool the agitating air to at least atmospheric temperature after it leaves the blower. Likewise, since some heat will necessarily be carried by the air even after partially cooling, it will pay to reduce the volume as much as possible without affecting the quality of the ice.

Perhaps not one of the above named means of maintaining a high suction pressure can be truthfully said to greatly reduce the cost of ice production. But the combination of all of these factors will undoubtedly reduce operating costs appreciably. Conversely, the neglect of all or most of the measures outlined above may seriously affect profits in this day of keen competition.

This thing called POWER FACTOR——

Part II. More regarding induction and energy components. Vector relations. Getting rid of the induction component and the counter-electromotive force.

HELLO, CHIEF, how about a little more dope on power factor this afternoon? You probably haven't anything to do anyway so I thought I'd give you a chance to spout forth knowledge."

Val threw his hat on the bookcase with careless abandon and parked himself in the chair opposite the engineer's desk.

"Well, I wondered when you'd blow in again," exclaimed the chief engineer. "I thought perhaps that last session we had was too much for your frail intellect and that in despair you jumped into one of your vats of varnish."

"Oh, yeah? Well, old timer, I guess you don't realize what you're up against when you match your intellect against that of the chemist; just keep in mind, this modern world couldn't run without chemists——"

"And it doesn't seem to be able to run with them either," interrupted the chief, putting away his slide rule and getting out a pad of paper. "Chemists! A gang of half-baked bottle washers——"

Val laughed.

"Bottle washers, eh? Well, at least that's more dignified than slinging coal with the black gang, but have it your way, I won't argue the matter. I wouldst converse with you about induction components, phase displacements and such highbrow things. What have all these things got to do with my fuses blowing?"

"Well," said the chief, "I see I'm in for it. Let's see where we were? I believe I made clear to you that the effect of inductance is to produce phase displacement and that the counter-electromotive force opposes *not* the impressed electromotive force, but the induction component of the impressed electromotive force—you understand that now, don't you?"

"Yes, I see that pretty well now. The counter-electromotive force opposes only that component of the impressed electromotive force which is used in overcoming the effect of inductance. The current which flows in the circuit, however, is due not to the impressed voltage but to the energy component of the impressed voltage. Since the value of the energy component is always equal to the difference between the impressed voltage and the induction component of the impressed voltage and since the later is at a maximum when the circuit is first closed, it follows that the current rises to its steady value, gradually. Have I got that straight, chief?"

"Fine—much better than I expected. Now, keep these facts in the back of your head for a while and let's go on. In our last talk I brought up the flywheel analogy, remember?"

"Yes."

"All right. Suppose instead of merely turning a flywheel in one direction we apply, by means of a connecting rod, an alternating torque tending to rotate the flywheel first in one direction and then in the opposite direction. In other words, we try to rock the wheel back and forth, say, through a third of a revolution. If the wheel is a heavy one (that is, it has considerable mass) it is evident that the driving torque must be reversed some time before the wheel actually reverses in order to overcome the effect of its inertia. Just before the wheel reaches the end of its travel in one direction, torque (force) must be applied, first to bring the wheel to rest and then to accelerate it in the opposite direction. The motion of the wheel, in other words, will lag continually behind the driving torque.

The Induction Component is always at a maximum when the Current is at a minimum.

"Now, I'm getting a little bit ahead of my story, but the displacement between the acting torque and the motion of the wheel is equivalent to the displacement in electrical degrees between the impressed voltage and the current in an alternating current circuit, in other words, the power factor."

"Power factor? Well, now we're getting down to the well known brass tacks," exclaimed Val.

The chief continued.

"In an alternating current circuit, the impressed electromotive force varies in the same way as does the force actuating the flywheel and if the circuit contains inductance, this impressed e.m.f. (which corresponds to the actuating torque in the flywheel analogy) reverses before the current. In other words, the current lags behind the voltage a certain length of time which can be expressed in terms of angular or electrical degrees.

"During a portion of the cycle, therefore, the impressed electromotive force and the circuit current are acting in opposite directions, a condition which seems

impossible. It is easily explained, however, when you recall that a counter e.m.f. of self induction is present and that the circuit current is the result, not of the impressed e.m.f. nor of the counter e.m.f. but of the combined effect of these two e.m.f.'s which may be called the active e.m.f. or the energy component of the impressed e.m.f."

"You mean, the active e.m.f. is the sum of the counter e.m.f. and the impressed e.m.f.?" asked Val.

"Not the arithmetical sum but the *vector* sum,"

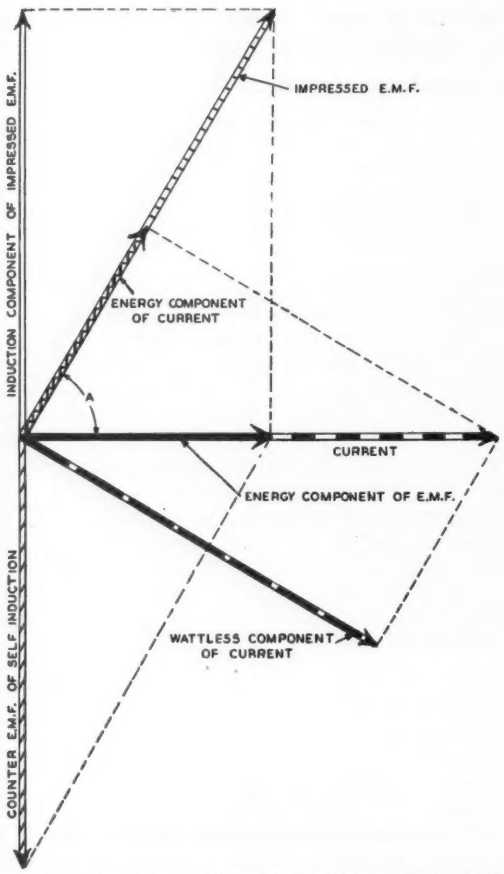


FIG. 1. VECTOR RELATIONS BETWEEN VARIOUS COMPONENTS OF AN ALTERNATING CURRENT CIRCUIT

replied the chief. "Here, perhaps I can make this clearer by means of a diagram (Fig. 1). In this diagram, assuming the vectors to have a counter-clockwise rotation, the impressed e.m.f. *leads* the current by an angle A. In forming a conception of what this means, think of the flywheel analogy again—remember that it was necessary to apply a force in the opposite direction from that in which the wheel was moving, some time before the wheel actually reached the end of its travel, that is what I mean by 'lead'. Get that?"

"Okay, professor,—proceed with the analysis."

"Very well, then. Now, as I pointed out before, the impressed e.m.f. may be considered to be made up of two components, the induction component and the energy component, which are at right angles to each other."

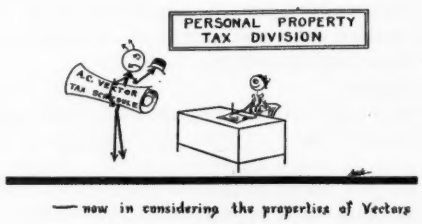
"Why are they at right angles? Why couldn't they be displaced a different amount?"

"That's a good question—I'm glad you asked it. To explain it, I will go back to our last discussion. You may recall, perhaps, that when I was explaining the presence of the counter e.m.f. in the circuit, I asked you at what period of time the current was changing most rapidly? And you said, 'At the instant the circuit was closed,' that is, when the current was zero. At that instant, also, we found that the value of the counter e.m.f. and, therefore, the induction component of the impressed e.m.f. was a maximum. In other words, the induction component is always a maximum when the current is at a minimum. Now, since the energy component of the impressed e.m.f. is always in phase with the current, it follows that the induction component is always at a maximum when the energy component is zero.

"Now in considering the properties of vectors, if we assume that the length of the projection of a rotating vector, e in Fig. 2, upon the horizontal line MN represents its absolute magnitude then it is obvious that two vectors X and Y have maximum and minimum values respectively when they are displaced 90 degrees as shown. It is for this reason then that we represent the induction component and the energy component of the impressed e.m.f. 90 degrees displaced from each other. Understand?"

"Yes, I think so," assented Val.

"You think so? Well, you should know. Perhaps it will be more clear to you if we consider our flywheel illustration again. In starting the flywheel from rest, when does the inertia effect exhibit itself most strongly? At the instant before the wheel starts to move, doesn't it? The very instant the wheel starts to move, the resistance to motion is reduced ever so slightly. So, you see, here again the resistance to motion is a maximum

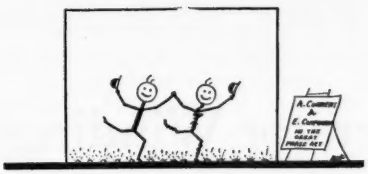


when the motion itself is zero. Vectorally this would be represented by a displacement of 90 degrees.

"Now, to get back to our main discussion. From what I told you before you know that the counter e.m.f. opposes the induction component of the impressed e.m.f., hence it is drawn opposite to the induction component in a downward direction as shown in Fig. 1. Furthermore, since the energy component is the vector sum of the impressed e.m.f. and the counter e.m.f. it is merely necessary to complete the parallelogram and to draw the diagonal in order to find the value of the energy component.

"This energy component, you see, is in phase with the current. It is the *only* e.m.f. which actually exists in the circuit and for this reason *must* be in phase with the current. You're kinda quiet today, aren't you, Val, or is this too much for you?"

"Quiet?" exclaimed the young chemist, "Why, you've got your nerve. What else would you expect me to be with you spouting forth knowledge? I can't get a word in edgewise. And don't worry about a simple



The energy component is always in phase with the current

little thing like this being too much for me. Compared to the chemistry of phenolic resins, this stuff is just A B C. But never mind the wise cracks, don't you know that a professor should never insult his students? What else do you know about power factor?"

"Fine," said the chief. "I see you're all right, I just thought you might be ill. Well, there is little more to tell in regard to this particular part of the problem. I hope you understand now that there is only one current in the circuit, the line current, and that this is always in phase with the available or energy e.m.f.

"Now in the same way that we assumed the impressed e.m.f. to be the resultant of two components, so can the line current be resolved into two components, a power or energy component and a wattless component. The energy component is of such value that when it is multiplied by the impressed e.m.f. in volts, the product will be the actual power in watts taken by the circuit. To satisfy this definition, this energy component naturally must be in phase with the impressed voltage as shown.

"The other component of the line current, the wattless component, is that current in amperes which, when multiplied by the impressed e.m.f. in volts gives the apparent *power* or volt amperes taken by the circuit. By this definition, the wattless component must differ from the energy component, by a phase difference of 90 degrees. Do you follow all this?"

"Yes, pretty well, chief, only it is difficult to keep all these different components in mind. This vector diagram is quite clear, but I wonder whether you can represent the same thing by means of the usual sine wave diagram. I can understand that better."

"Sure," replied the chief, tearing a sheet off his pad and busying himself drawing the diagram shown in Fig. 3.

"There," he said a few minutes later as he finished it. "In this diagram, as you will note, I have merely projected the vectors of Fig. 1 along a time axis."

"That's fine, chief," said Val, studying the diagram. "I see now, what you mean when you say that the active e.m.f. is the only e.m.f. really acting in the circuit. The induction component and the counter e.m.f. oppose each other at every instant. Therefore, they do not actually exist."

"Yes," commented the chief. "If you always keep that definitely in mind you need never be confused in visualizing power factor phenomena. Note that at the time the counter e.m.f. (and therefore also the induction component) is passing through zero, the only voltage acting on the circuit is the impressed e.m.f. for at this instant this is equal to the active e.m.f. Also, at the instant the impressed e.m.f. is passing through zero, the only voltage acting in the circuit is the counter e.m.f. since this at this instant is equal to the active e.m.f. But I've got to go—I promised to drive Elmer up to Newark tonight so I am going to let you off now."

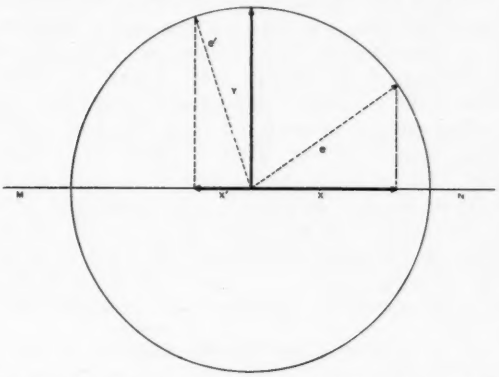


FIG. 2. THE PROJECTION OF A ROTATING VECTOR UPON THE HORIZONTAL LINE M-N REPRESENTS ITS ABSOLUTE MAGNITUDE

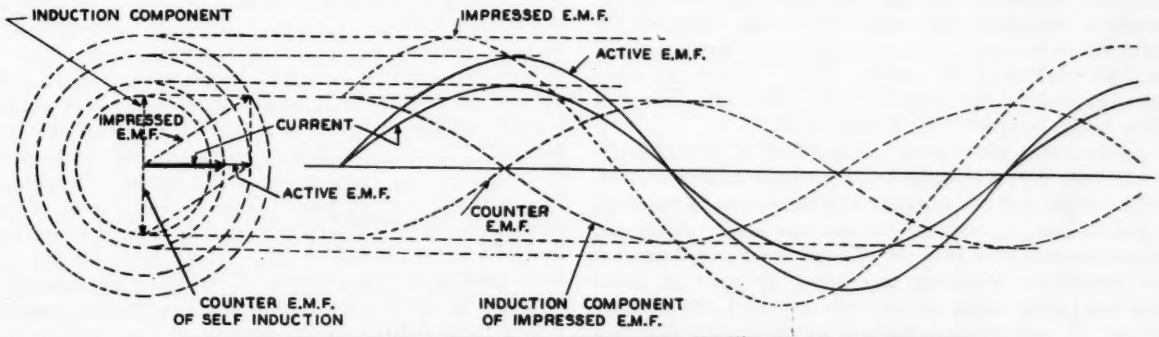


FIG. 3. WAVE DIAGRAM SHOWING VARIOUS COMPONENTS OF AN A. C. CIRCUIT

"Newark again, eh?" exclaimed Val, knowingly. "Seems to me you birds are going to Newark quite regularly these days. Well, all right, I'll see you tomorrow. Thanks a lot, chief, for the dope, and lay off that Newark homebrew—it's bad stuff."

THE EFFICIENCY of the conversion from electric energy into heat energy is 100 per cent. The entire energy of one kilowatt hour can be converted into heat with no losses, to the ratio of one kilowatt-hour equals 3412 B.t.u. The efficiency of the application of electric heat is high; one reason is the lack of any loss through heating air for combustion, and another, the more compact design usual to electric heaters because of the absence of ventilating requirements.

POWER PLANT ENGINEERING November 1932

Points to Consider when

Repairing Motor and Generator Windings

By MARIN PHILLIPS

IN THE MAINTENANCE of electrical equipment the operating man who has his company's interests at heart is often faced with a problem that is hard to solve in a satisfactory and lasting way. I have in mind the repairs on the winding of motors and generators. A coil will often ground or burn out in a stator or armature winding that will cost $200 to $300 to completely rewind. Here is where the problem of deciding the right thing to do becomes so difficult. The repairman is faced with the question of rewinding at a cost of, say $250, and having a reliable and lasting repair job, or patching up the winding for a few dollars, and being constantly faced with unreliable operation and imminent failure.

Can Coils Be Salvaged?

When a new "rewind" is decided upon another question comes to the fore. "Can the coils be salvaged?" Before it became the practice to dip the windings in a tank of insulating varnish after the coils were placed in the slots and then baked in an oven, it was easier to salvage and make repairs on the winding than at the present time, when the coils are embedded in the slots. However, the old practice of salvaging and repairing was of a doubtful outcome, as there was always the danger of damaging the insulation on the inside of the coils, where it could not be seen, no matter how carefully they were taken out of the slots. These coils would often show up well under inspection and tests and then fail after being in service for a short while.

Unless the coils come out of the slots in exceptionally good condition no attempt shuld be made to re-use them, as the chances of their failing in a short time is too great a risk to take, to pay for the savings made. After all, when the cost of a new set of coils is balanced against the possibility of having to rewind the machine again in a short time, when the old coils are used, the junking of the old coils doesn't look so extravagant. The new set of coils will show up as the cheaper investment in the long run.

When the coils are salvaged for a "rewind" job they will probably have to be retaped. Then, too, some of them will be pulled out of shape, making it difficult to replace them in the slots. This will require forcing and hammering which may damage the coils that have been kept in good condition until now. Then there is the increase in time required, in carefully trying to remove the coils in good condition. When the coils have to be retaped by hand it will be an expensive operation, the cost of which would go quite a way towards the purchase of a new set of coils. Very often considerable time is spent in removing the old coils with the idea of salvaging them only to have to throw them away and use new ones, as the condition of the old ones makes them unfit for re-use. Where the coils have to be junked, the armature can be stripped in a fraction of the time required for a salvage job.

The condition of the coils will depend on several factors, such as length of time in service, temperature at which they have been operating and their general condition of cleanliness, oil soaked insulation, or the absorption of chemical fumes. Where the coils have been in the slots for a long time the insulation will have become brittle, and it will be just about impossible to get them out of the slots without cracking or injuring the insulation. If the coils are oil soaked the tape around the outside of the coil will be rotten and easily torn. This will remove the protection from the coil turns, allowing the insulation on them to be damaged. The absorption of chemical fumes can be detected by the megger test or a high-voltage test of around two and one-half to three times the operating voltage for 220-440 and 550 v. motors. Under this test the chemical or acid will be revealed by several sparks around the winding at the ends of the slots.

Heating Often Facilitates Coil Removal

Where the windings have been dipped in varnish and baked after the coils were placed in the slots, their removal can be made easier by heating the winding first. The heating may be accomplished by passing current at low-voltage through it, so as to limit the current to the required amount, or by placing the winding in an oven. Where the winding is heated in an oven it should be allowed to remain in it until the coils are thoroughly heated through in order to make the inside of the coil flexible. Probably the most satisfactory way of heating the winding is by passing an electric current through it. The coils will then be heated from the inside out. These precautions to be taken only when it is desired to salvage the coils for a rewinding job. Where the coils are not to be used again the problem of stripping the armature or stator in the shortest time possible is the one present. Under these conditions the heating of the winding can be more quickly accomplished with a large torch such as a welding torch. The heating is desirable whether the coils are to be salvaged or junked.

Another method that will be an aid in cutting down the labor required to strip the core of the winding, is, to soak it in gasoline for a day. This means that on a direct-current armature the winding must be stood on end in a container (with the commutator end up) holding the gasoline and filled just full enough to cover the slots, so that no gasoline gets on the commutator or mica ring. When using this method of removing the coils, it is necessary to take the usual gasoline precautions. For safety against accidents and fires the work must be so isolated that it will be away from any possibility of contact with sparks or flames. When the winding is removed from the gasoline, the coils can be removed by the use of a long slim chisel or fibre wedge, driven into the slot below the coil.

Varnish remover is sometimes an aid in loosening the

coils in the slots. There are a number of varnish removers on the market. You will have to select with care, if the coils are to be used again, to prevent using a remover that will have a deteriorating effect on the coil's insulation. Of course, if the coils are to be junked, the varnish remover's effect on the coil may be disregarded.

On machines that have semi-closed slots or are hand wound, the solution of the rewinding problem is to remove the old winding in the quickest way and put in the new winding.

Repairing Machines with Bar Windings

On large machines with bar windings a considerable saving can often be made by thoroughly cleaning the coils and re-insulating them. Sometimes a saving can be made in rewinding medium size machines having only a few turns in the coil, by carefully reinsulating the turns and retaping the coil. The amount of salvaging that can be profitably applied to an old winding will depend on the labor cost. If experienced operators, whose time would otherwise be lost, are available, considerably more work can be put on the old winding than is possible if a charge for extra labor has to be made.

The repairs to old windings often present a problem of first importance to the maintenance man. "Should the winding be repaired, or replaced?" being the problem. If one or two coils are injured in the winding it is sometimes possible to raise the top sides of enough coils to get at the injured ones for replacement. However, the condition of the winding often prevents doing this. If the winding has operated at high temperature over a period of years, or the winding being oil soaked, the insulation will crack and skin to such an extent that in raising the coils they may be so badly damaged they will soon fail when put back into service.

In most cases the cheapest and most satisfactory way to repair an old winding, where only a few coils are injured, is to cut them out, provided, of course, the rest of the winding is in good condition and tests free of faults with the defective coils cut out. Some windings will operate satisfactorily with several coils cut out. Wherever possible, advantage should be taken of this method of repair. Sometimes the motor so repaired can be transferred to unimportant drives, where a failure will not seriously affect production, and operated several years, giving as good a service as a new winding. I am at present operating two 50 hp. motors that had two coils cut out five years ago.

Reports made to the British Electricity Commission for 1931 show 538 stations operating to deliver 12,812,700,970 kw-hr., an increase of 3.9 per cent over 1930 with fuel consumption decrease of 0.69 per cent. For 300 steam plants, the range was from 1.57 lbs. of coal per kw-hr. in the largest to 10.52 lb. in the small plants. For 162 oil-engine plants, the fuel used was from 0.63 lb. to 1.17 lb. per kw-hr. One large producer-gas plant used 2.06 lb. of fuel per kw-hr., while 11 smaller ones took 3.13 lb. Best thermal efficiency was 31.8 per cent from an oil-engine plant with load factor of 28 per cent, the fuel being 0.58 lb. per kw-hr. Deptford West station showed the best efficiency of steam plants, 24.02 per cent, but lowest coal consumption was claimed by Kearsley station, 1.2 lb. per kw-hr. at thermal efficiency of 23.85 per cent.

Spare Transformer Installation

Two transformer banks were installed a few years ago; one bank to take care of the existing load and the other for emergency use. When installed they were considered of sufficient capacity to take care of quite a future load increase. At the present time the load has reached the point where one bank will not carry it safely and both banks must be used, leaving nothing in case of transformer failure, but an overloaded bank. Installing another bank of transformers was considered, but the cost was prohibitive so it was decided to install one spare transformer that could be cut in to replace any transformer in either bank. Disconnecting switches were considered and rejected as the entire bus structure would have to be rebuilt.

The following plan was used. The spare transformer was set beside number one bank and a new section of bus put up at right angles to the present bus. The secondaries of the banks being Y connected, the neutrals were tied together permanently with the neutral of the spare transformer. The remaining three spare

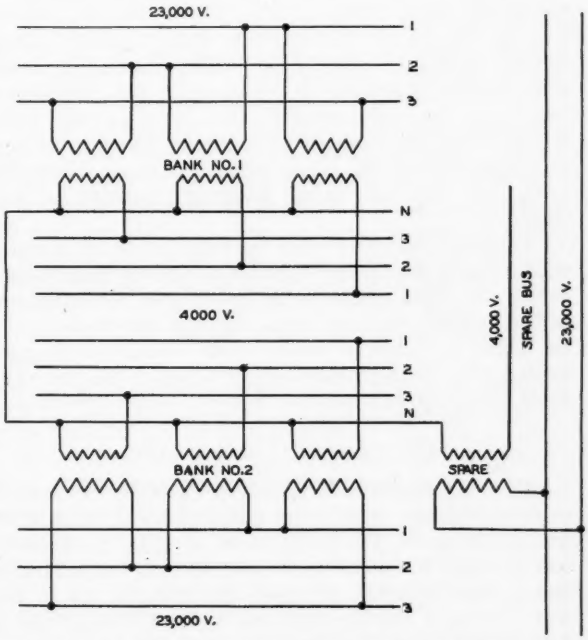


DIAGRAM OF CONNECTIONS FOR SPARE TRANSFORMER

transformer leads were connected to the new bus as shown in the diagram. Lugs were soldered to the ends of the old bus on each bank and a set of three flexible connections were made up to connect the old bus to the new. In case of transformer failure, the leads connecting the faulty transformer to the bus are removed and the flexible connections slid along the spare bus and connected to the proper lugs on the bank bus. This can be done in a short time during which the other bank can safely carry the overload.

Revere, Mass. H. Kroitzsh.

It is generally accepted as a fact that many of our metallic elements offer no resistance to an electric current at absolute zero, —273.1 deg. C.

POWER PLANT ENGINEERING November 1932

OIL-FREE FEEDWATER

By
Edward P. Schinman
Chemical Engineer.
The Permutit Company

Foaming Is Reduced, Heat Losses Diminished by Oil Removal, Using Filters. Condensate Is Made Usable and Makeup Water Is Decreased. Oil Removal Plant Arrangement and the Results Obtained.

OIL IN BOILER feedwater will deposit on the internal surfaces of the boiler, causing burning, blistering and failure of boiler tubes and plates. Its heat insulating effect is even greater than boiler scale thus wasting fuel and it aids scale forming, since it helps catch and cement precipitates on the wetted surfaces of the boiler.

Although both mineral and animal oils form emulsions, many animal or compound oils will also saponify in a boiler due to reactions with the caustic salts in the boiler water. When this occurs, it not only causes foaming but the circulation of the water tends to collect the oily soaps into solid "grease-balls," which vary from small pellets to spheres of considerable size. Wherever they touch the boiler surfaces, they leave a greasy coating with high heat-insulating property, which gives rise to overheating of the metal and its ultimate distortion or failure. Oil also causes foaming, resulting in wet steam.

Foaming interferes with the lubrication of engines, which causes the engine operator to employ more lubricating oil. This increases the amount of oil returning to the boilers, which in turn increases the tendency of the boiler to foam; a vicious cycle which can be prevented only by the installation of a proper oil-removing filter, allowing only oil-free water to enter the boiler.

Heat Losses Caused by Oil

Sir John Dunston** found by carefully conducted experiments that, with a fire temperature between 2190 and 2500 deg. F., the temperature of ½-in. thick metal was 280 deg. F. on the water side when it was perfectly clean. The addition of 5 per cent mineral oil to the water brought the temperature up to 310 deg. and a 3/64-in. layer of grease increased it to 518 deg.

Figure 1 shows that to transmit 17,500 B.t.u. per sq. ft. of boiler surface per hour requires a temperature difference between the boiler plate and the water of 100 deg. F. when the plate is clean and 1120 deg. when insulated with grease. This increase in temperature difference can be obtained only by increasing flue gas temperature, with the result that a considerable amount of heat is lost up the stack. Maximum safe operating temperature for boiler steel is 900 deg. F. and increase to 1200 deg. or more due to oil explains frequent tube failure where oil is present.

Sources of oil contamination are the exhaust from reciprocating engines, oil in condensate from process heating, and oil which has been added to prevent corrosion in return lines; although not general practice, this last has been found helpful in several instances.

**Trans. Inst. Naval Engrs. Vol. 34, p. 130.

Various Methods of Oil Removal

Oil separators, operating by impinging the steam against a plate on which the oil condenses and drops into a reservoir, or by injecting into the steam a spray of water which carries down some of the oil will remove most of the oil yet may not produce a condensate clean enough to be satisfactory for boiler feeding.

Stocking condensate filters, depending on cotton or terry-cloth disks and cartridges or fibrous strainers to

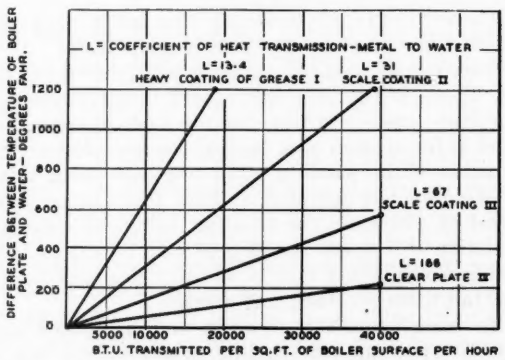


FIG. 1. SCALE AND GREASE REDUCE HEAT TRANSMISSION

remove and retain the oil have comparatively large voids or interstices, consequently oil in the emulsified state may readily pass through. In this connection it should be noted that the oil which is in emulsion causes most of the trouble with foaming and priming and the burning and blistering of tubes.

Removal of the cloth stockings and their cleansing are tasks requiring considerable time and labor and, unless the cloth is cleaned in time, the accumulation of oil causes high pressure drop which is liable to tear a hole in the cloth through which the oily condensate will then pass.

Filters with absorbent granular filter media contain special absorbent material designed to remove oil both in suspension and emulsion, by absorption in the cellular structure of the filtering medium.

When the filtering medium becomes clogged with oil, it must be removed and burned free of the accumulated oil, or entirely replaced, the frequency of this reburning or replacement depending on the amount of oil present in the condensate. Reburning causes a loss of about 5 per cent or more of the material, besides being a dirty and disagreeable job, requiring a kiln and keeping the filtering plant out of operation for a considerable period of time. After 3 to 5 reburnings, the filtering medium must be replaced.

Oil Removal Filter

With proper pH control, oily condensate can be coagulated with aluminum sulphate or copperas (iron sulphate) so that the oil particles conglomerate into larger masses. The addition of alum or copperas results in the formation of a gelatinous precipitate (called floc) which entrains the minute particles of oil and other suspended matter, thus forming larger particles, which are then readily removed by filtration through a bed of suitable silica, properly graded and of the proper depth, contained in a steel pressure filter of either vertical or horizontal type. By this method, both the oil in suspension and emulsion are removed. A secondary system of header and lateral piping just above the strainer system provides for blowing air through the filter bed during cleaning. If compressed air is unavailable, it can readily be obtained by the installation of a steam jet compressor to supply the required volume of air for this agitation.

At intervals of 3 to 8 weeks, depending on the amount and kind of oil removed, it is necessary to scour the filters free from the accumulated oil which is not removed during the normal backwash. To carry out this operation readily, a solution tank is connected to the wash inlet line and a steam injector is provided to force the hot cleansing solution from the tank into the filter. Accumulated oil is discharged to the sewer through the waste pipe, without unloading the filter, using clear cold water for washing.

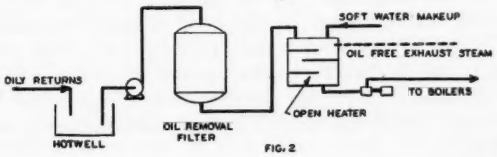


FIG. 2

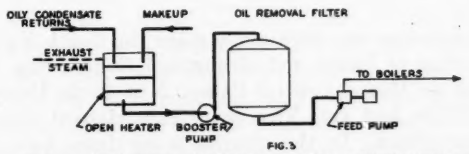


FIG. 3

FIG. 2. FILTERS HANDLE ONLY CONDENSATE
FIG. 3. FILTER HANDLES ALL FEEDWATER BUT AT LOW PRESSURE

Heat Loss in Unused Condensate

With makeup water at 65 and condensate at 110 deg. F., every 1000 gal. of condensate, due to its 45 deg. extra temperature, contains $45 \times 8.33 \times 1000 = 375{,}000$ B.t.u. added heat, or the equivalent of 40 lb. of coal burned at 70 per cent boiler efficiency. Since condensate is soft water, the cost of softening the equivalent amount of water must be added (2 to 5 cents per 1000 gal.) and the cost of the water itself (3 to 15 cents per 1000 gal.) should also be included.

Actual loss then sums up as follows:

40 lb. coal at $5.00 per ton	$0.10
1000 gal. water at $0.03	0.03
Softening 1000 gal. water	0.03
Total loss (per 1000 gal.)	$0.16

Since pure condensate contains practically no solids, blow-down from the boiler is reduced in proportion to the amount of makeup replaced by condensate, which adds another cent or two to the savings, making a saving of $0.16 to $0.18 per 1000 gal.

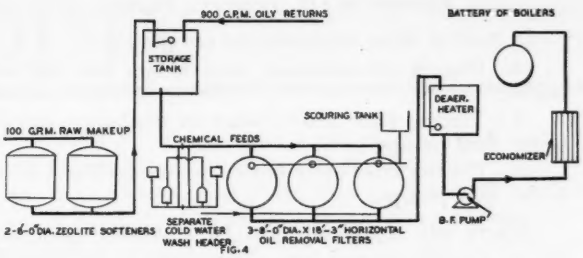


FIG. 4

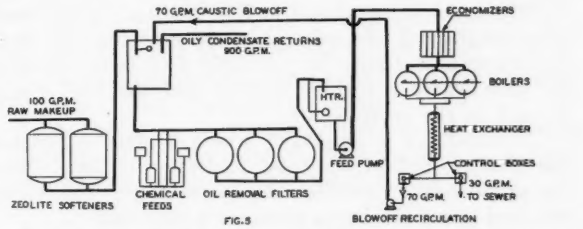


FIG. 5

FIG. 4. SOFTENING, OIL REMOVAL, AND DEAERATION BY THIS ARRANGEMENT
FIG. 5. BLOWDOWN WATER USED TO SUPPLY ALKALINITY FOR COAGULANT ACTION IN OIL REMOVAL

At the present cost of chemicals, using alum for the coagulant and soda ash as the alkali the cost of operating an oil-removal filter is about 0.5 cent per 1000 gal. Scouring the filter every 30 days costs approximately 0.25 cent per 1000 gal. Cost of labor, 20 min. per day for washing and about 1 hr. every 4 weeks for scouring is inappreciable. To offset this cost, 0.75 cent per 1000 gal., there is a direct saving, as shown above, of an average of 17 cents per 1000 gal. of oil condensate reclaimed.

If makeup contains appreciable amounts of alkalinity, a portion or all of it may be mixed with the returns before going to the oil removing filter, thus saving some or all of the alkali that must otherwise be introduced ahead of the filter to react with the coagulant. In such cases, however, the filter size must be increased to handle the larger flow due to the addition of the makeup. Economic study should be made to determine whether it is cheaper to feed alkali or make use of the alkalinity in the makeup by installing a larger filter.

Amount of makeup water required, depending on its alkalinity, in order that 30 p.p.m. of alkalinity (the amount usually required for coagulation) may be present in the final mixture of condensate and makeup is as follows:

Alkalinity in makeup p.p.m. 50, 100, 150, 200.

Gal. makeup per 100 gal. condensate to give mixture containing 30 p.p.m. alkalinity 50, 42, 25, 18.

If the alkalinity in the makeup is small, say 50 p.p.m., requiring 50 gal. of makeup for every 100 gal. of condensate, the oil removal filter must be enlarged about 50 per cent. It is, therefore, usually inadvisable to use makeup water for alkalinity purposes, unless it contains some 150 p.p.m. or more of alkalinity.

Where boilers are equipped with a continuous blowoff system, the caustic blowoff water may be used to supply the alkali required for the coagulation. This also raises the pH of the feedwater thus aiding in checking corrosion.

Layout of Oil Removal Plant

In general three arrangements are possible:

(a) Placing oil removing filter before hot well or heater.

(b) Placing filter after heater on discharge side of boiler feed pumps.

(c) Placing filter after heater but on suction side of boiler feed pumps.

Where oily condensate can be separated from the rest of the returns and from the makeup so that the oil removal filters have to handle only the oily stream itself, scheme (a) as shown in Fig. 2 is usually the most economical. But the exhaust steam entering the open feedwater heater must be relatively free from oil, as is the case where a turbine is bled and the bled steam is used in the open heater.

Scheme (b) is employed where returns constitute the greater part of the total feedwater stream, where the exhaust steam entering the heater is oily and where the feed pump discharge pressure is moderate.

Scheme (c) is used under the same conditions as scheme (b), but is to be preferred when the feed pump discharge pressure is high, Fig. 3. A booster pump discharges the oily effluent of the heater through the oil removing filter to the boiler feed pump, preventing flashing in the feed pump suction. The filter thus carries low working pressure, avoiding the expense of extra heavy filter shells and piping.

Practical Results

Results obtained by the use of this type of oil removal equipment at one plant were as follows:

At the time under consideration the boiler plant consisted of:

No. of boilers	Rating boiler hp.	Type of Boiler	Steam Pressure, lb.	Load, % rating
8	866	Hor. water tube	275	175
4	455	Hor. water tube	150	135
2	509	.....	150	135

Total amount of feedwater was 60,000 gal. per hr. of which 90 per cent was condensate returns and the other 10 per cent raw water treated by a lime soda process.

After investigation, it was determined that repeated burning out of boiler tubes was caused by the presence of much oil in the condensate and feedwater due to the use of a large number of reciprocating units. In addition to tube burnouts several foaming difficulties occurred. After installation of oil separators, tube burnouts still continued.

Inspection showed the presence of moisture and sediment in the superheater, deposits of oil sludge in the economizers, deposits in the tubes showing 12 per cent of oil, evidence of carry over in the dry pipes and some deposits in the turbines, also showing a high oil content. When one of the boilers was taken down for inspection, two barrels of oily deposits were removed. After a complete study of several types of oil removal equipment offered by various manufacturers and extensive surveys in plants using each type of equipment, it was decided to install oil removal equipment of the type described above.

Installation of three horizontal, pressure, oil-removal filters 8 ft. diameter by 18 ft. 3 in. long, together with the necessary chemical feeds and scouring tank was made, the softening plant adopted being two 8 ft. diam. vertical zeolite softeners.

Flow diagram for the feedwater is shown in Fig. 4. Makeup water passes through the softeners, into an elevated storage tank which also receives the oily condensate. The mixture, to which the necessary amount of coagulant has been added, then passes through the oil removal filters to the deaerating heater and to the boilers.

With this arrangement the operating difficulties such as burning out of tubes, foaming, clogging of superheaters and steam traps, erosion of turbine blades were completely overcome.

Later, this plant installed a continuous blowoff system with heat recovery, which made possible utilizing the caustic blowoff water for supplying the alkalinity used in coagulating the mixture of oily condensate and makeup water, when coagulant is used. With some types of oil, the filter beds exercise oil removing powers so that coagulant is only required at the beginning of the filter run. In some cases after the filters have been in service for some time and the beds have become seasoned, the use of the coagulant can be omitted. The use of boiler blowoff water added to the feed stream increases the pH value of the feed water, thereby providing protection to the feedwater system against corrosion. Present arrangement, including recirculation of the boiler blowoff water, which has proved entirely satisfactory is shown in Fig. 5.

Exhibitors are working to make the Tenth National Exposition of Power and Mechanical Engineering to be held at the Grand Central Palace, New York, December 5 to 10 the best yet. Two years have elapsed since the last exposition. In the interim many lines have been completely revamped and research has produced new designs and devices to meet the demands of changed economic conditions. To date, 305 firms have signed up for space.

The period through which we have been passing has provided time and opportunity for engineers and managements to survey their power facilities and plan improvements that will effect large savings in operation when production starts upward. Many such plans are already on paper, awaiting the necessary appropriations as soon as available. There remains only the selection of the specific equipment. The Exposition will show what the equipment manufacturers have been doing and afford an opportunity to make direct comparisons. The management will concentrate its efforts this year on inducing such engineers to visit the show in the belief that it will be to their distinct advantage. Quality rather than numbers will be the goal.

Among equipment showing improvements will be that for fuel preparation and fuel burning, for the collection of cinders and fly ash, furnace walls to lessen outage and maintenance, instruments and meters to record more accurately temperatures, flow and leakage so that waste may be more readily detected and prevented, draft gages for zoned air control, devices for maintaining proper feed water treatment, water-level indicators, traps to minimize leakage and maintenance and better to withstand high-temperature service.

OFF DUTY

We don't really know, but it is reasonably safe to assume that when an amorous fruit fly looks into the devastating red eyes of his lady love beside him, he experiences emotions not greatly unlike those of a young college boy gazing into the eyes of his favorite co-ed. For if he didn't, why would there be fruit flies? True, red eyes may not induce exactly the same emotional response that blue or brown eyes do but the difference in color we believe would not alter the fundamental fact that the two flies would be filled with the cosmic urge to reproduce their kind—that is, little fruit flies with red eyes.

"Fine," you may say, "but who cares? What about it?"

Well, that is just what we want to talk about. You see, for many years scientists have been putting these little flies, *Drosaphila,* into bottles and have kept close track of the color of their eyes, for they are not always red. Sometimes one appears with white eyes. And from watching them and noting the color of their eyes, the shapes of their wings, their body markings, they have been able to deduce certain general laws regarding heredity. The color of the eye, it can be shown, is transmitted from one generation to the next—it is an inheritable characteristic and follows the Mendelian law of heredity. You can do the same thing with plants or other animals. Mendel who first discovered the laws experimented with sweet peas. When certain strains of peas or beans are "crossed," the experimental biologists can tell almost exactly what to expect in the offspring.

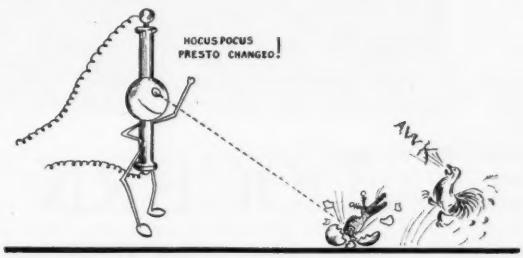
All this is interesting but the strange thing about these experiments is that though at times new species have appeared spontaneously, never have the scientists been able to create a new species by any method of "control" at their command. No matter how a plant or animal might be injured or deformed by subjecting it to extremes of all kind, heat and cold, chemical and electrical action, starvation, repletion, over generation after generation, the offspring always continued to sprout or be born in normal form.

This at least was the situation until, some years ago a new tool was placed in the hands of the biologist—the X-ray. As early as 1899 the X-ray had been turned on living matter but always with destructive results. But in 1904, a new startling fact was disclosed. It was found that by X-raying the egg of a worm, the course of development of that egg was markedly altered, and a little later when the eggs of a salamander were subjected to the X-ray, the animals that were hatched were not salamanders at all! The same experiments with hens' eggs gave similar results. Chicks hatched in due time but they were freaks of every conceivable variety.

Since that time much work has been done. The X-ray, it seems, is capable of effecting profound changes in the germ cells of living things. The germ cells, it should be understood differ from the cells of which the rest of a living body is composed in that their sole function is to produce a new generation—the pollen of flowers, the germ of an egg—any cell of egg or sperm is classified as a germ cell.

The X-ray, it appeared, could effect marked changes in the course of evolution. By irradiating the eggs of the fruit fly, the color of the eyes of the developed flies could be changed. In other instances a complete elimination of the sex factor was effected. As a result, individuals which normally were destined to become females, on fertilization of the egg, developed into males.

Thus in the X-ray tube for the first time we have available a means of influencing the substance of heredity, and as pointed out recently by C. P. Haskins of the General Electric Research laboratory, with it *the most stable part of a living thing, becomes the most easily modified.* This knowledge, too, gives us a clue as to why new species are produced in nature.



But when they were hatched they weren't chicks at all.

The importance of these discoveries can hardly be overestimated. Who knows but that some day we will be able to control this effect—to be able to produce new and better species at will. Already something of this sort has been accomplished, not necessarily, at will, but new species have been produced by subjecting plant seeds to the action of the X-ray. In 1930, for instance, two experimenters, McKay and Goodspeed, in working with cotton, produced one variety in which the mature head grew entirely free from the seed, so as to leave it naked and to eliminate entirely the tedious and expensive portion of the ginning process.

Indeed, the possibilities in this field are beyond the powers of imagination. Applied to human beings, we might produce individuals of any desired quality and form, from dumbells to geniuses. We could produce leaders to get us out of any sort of jam we might find ourselves in. Should we need a certain type of president, instead of getting just an ordinary mortal through cumbrous election methods, subject to vagaries of prejudice and emotion, as has always been the custom, from proper specifications sent to the X-ray laboratory one would be developed by orderly, scientific process. Upon completion he would be sent to the test shop and there, depending upon his reaction to such questions as, Do you favor repeal of the 18th amendment? or What are your views regarding a protective tariff? he would be accepted or rejected. Then, too, we might improve the ordinary run of mortals, at least to the extent of correcting our highly advertised deficiencies. Imagine how wonderful it would be if instead of being provided with a mere salivary system, we could be born with Listerine tonsils.

DOGERN *on the* RHINE

New $13,000,000 Hydroelectric Development on Rhine Will Develop 112,800 hp.

By A. J. LUCHINGER
Locher & Cie., Zurich, Switzerland

ON THE FRONTIER of Switzerland and Germany the river Rhine is going to be an ever increasing factor in the generation of hydroelectric power in Europe. Between Schaffhausen (Rhinefall) and Bâle, that is within a length of 85 mi. the Rhine has a total drop of 520 ft. This head will be ultimately utilized by 13 developments, of which 5 are already built and one, the Dogern, is in state of construction.

At Bâle the flow of the Rhine varies from a minimum of 10,000 c.f.s. to a recorded maximum of 200,000 c.f.s. The mean flow, which occurs in normal years at least during 182 days, amounts to 35,000 c.f.s. The recent developments on the Rhine are installed up to this capacity, conforming to the requirements of the best public interest.

The fact, that all these power sites are located on the frontier of two different countries, complicates somewhat their development. The normal way of handling this difficulty is as follows: The company of a new plant is formed by an equal number of partner companies in each country. The raising of the capital, the expenses and the output in power are equally divided between the partners. This procedure makes it necessary that the partners can sell their share of power in their respective countries. It would not be possible for a private company to build for exportation only, as the governments are issuing exportation licenses only for a few years at the time. This difficulty of the power market arose before the development of the Dogern plant. Germany has just now a market for the full power output of that plant, whereas Switzerland at the time can use no more power. It has now been agreed between the two governments, that the whole power of the Dogern plant can be used for 80 yr. in Germany, whereas the next plant to be built on the Rhine will furnish its full power for the same length of time to Switzerland, as soon as the market can absorb it. This agreement permitted the immediate construction of the Dogern plant.

Inland navigation on the Rhine is possible until now only up to Bâle. Beyond Bâle navigation will be possible only after impounding the flow of the river by a continuous series of weirs. All the power developments above Bâle have to make provisions for future locks. The completion of all power plants is therefore the first condition for the extension of the inland navigation beyond Bâle. It will never pay the navigation interests to build the impounding weirs on their own account.

Dogern Project

At the Dogern plant the main structures are the weir across the Rhine, a canal of about 2 mi. length parallel to the river and the power house with a short tail race connecting again with the Rhine. The head at the power house varies from max. 38 ft. (low water) to min. 23 ft. (extreme flood). The station output at normal head of 30 ft. will be 90,000 hp.

The design of the weir is governed by the fact, that in times of extreme floods practically no backing up of the present flood stages is allowed above the weir. The discharge area with all gates open has to be about the same as the natural profile before construction. This rule calls for large gates reaching down to the elevation of the present river bed. There will be installed 5 two-party stoney gates of 35-40 ft. height and 82 ft. width between concrete piers. The width of the openings of the different weirs has been gradually made larger during the last few years; the result being great economy. The largest openings for stoney gates constructed till now on the Rhine are those at Kembs below Bâle with 100 ft. width between the piers.

Piers and sills are founded on clayey marl of a hard and dense quality. The foundations of the cut off walls are carried down 24 ft. into the rock. This is necessary as protection against scour. The concrete sill and lower parts of the piers are faced by heavy granite stones, as a protection against the continuous flow of sharp sand and gravel in the water. (Fig. 2.)

Adjoining the weir on the right side of the river is the entrance structure to the canal. The water enters through 12 openings of 16 ft. height and 54 ft. width between concrete piers. The maximum entrance velocity is 3 ft./sec. The entrance sill is 16 ft. above the weir sill in order to keep off any gravel from the canal. An ice protection wall reaches down 5 ft. below water level, so that any ice or trash in the river will float along this wall and will be carried through the weir openings.

The normal profile of the canal has a bottom width of 160 ft. and slopes of 6:7. The water velocity will be maximum 6.5 ft./sec. The greater part of the canal is laid in gravel, but for a short length only it is cut through fundamental gneiss. The materials for the embankments can all be used from the excavation. The wetted profile is protected by concrete slabs.

In the power house will be installed 3 Kaplan turbines with vertical shafts, each connected to an electric generator. Each turbine has a capacity of max. 37,600 hp. at a maximum head of 38 ft. and 75 r.p.m. Each turbine passes 10,700 c.f.s. The runner with an outside diameter of 23 ft. has 5 movable blades. Kaplan turbines of exactly the same size were put in operation two years ago in the Rhineplant Ryburg Schwörstadt and reached efficiencies of max. 92.7 per cent at 24,000 hp. The efficiencies at full load are 87 per cent, at 1/3 load still 90 per cent. The draft tubes of both plants are of the elbow type with vertical and horizontal guidewalls and a very long horizontal part after the bend. (Fig. 1.)

There will be no intake gates in front of the turbines, but only a series of stop logs, which can be used for repairs of either of the three units. The shut down of the machines is effected by closing the guide vanes of the turbines. In case of any damage to the guide vane regulation, the runner blades can be turned till the flow is cut down to one-sixth of the full discharge.

Construction

A development with weir, canal and power house makes it possible to start construction on all three projects at the same time without interfering with each other.

The weir across the Rhine is built partly with pneumatic caissons, partly between cofferdams of steel sheet piling. The rock at the weir site is about 30 ft. below water level; overlaying the rock are 0-30 ft. of gravel. The piers and cut off walls of three openings in the deep and swift river section are built upon steel caissons, which are sunk from steel scaffoldings. The piers and sills in the shallow section are built between cofferdams. This combination of pneumatic caissons with steel sheet piling results in safe and economic construction. In order to pass the flow of the Rhine during construction

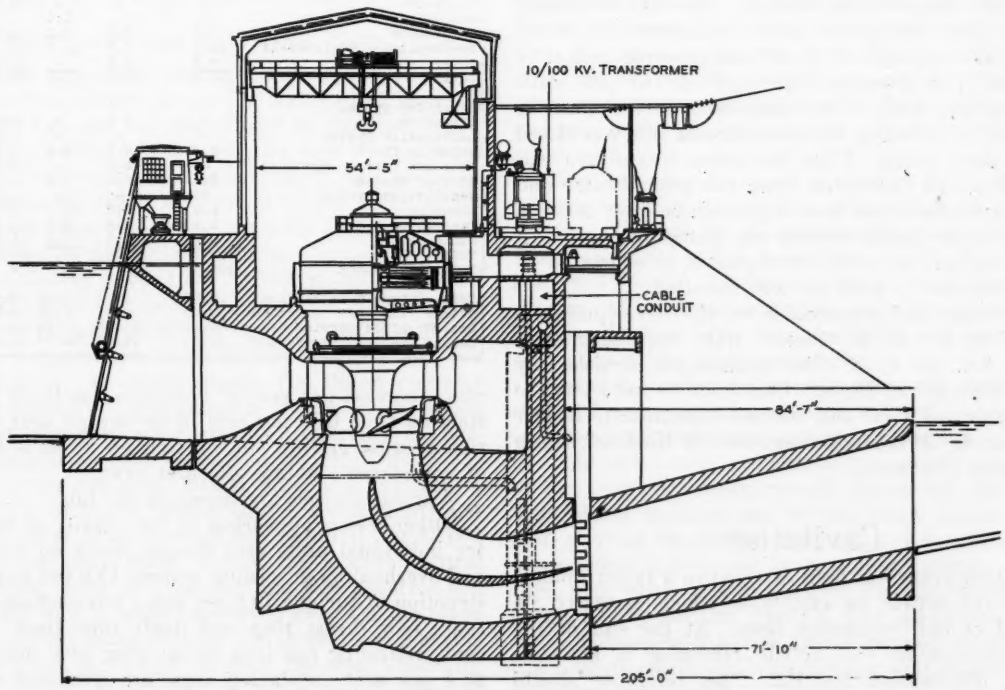


FIG. 1. CROSS SECTION OF THE DOGERN HYDROELECTRIC PLANT

without backing up the water too high above the weir, construction is carried through in four succeeding stages, closing off only a small part of the river at a time.

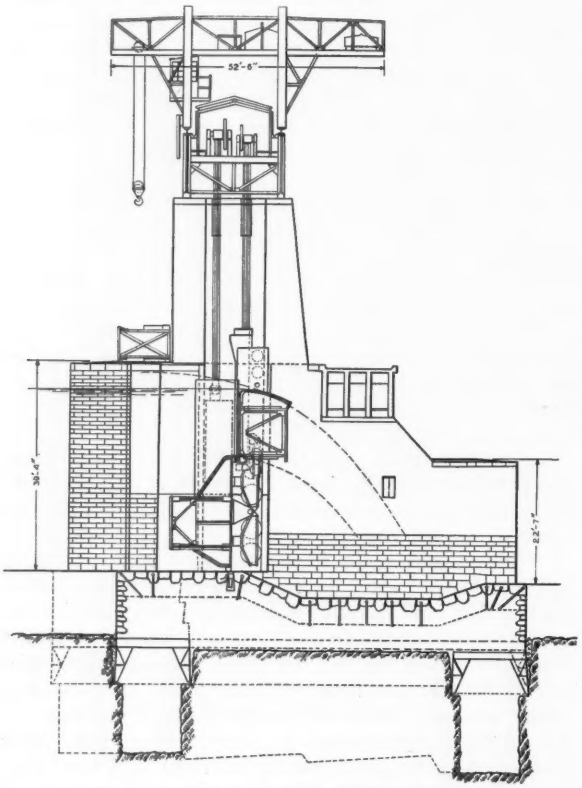


FIG. 2. SECTION OF THE DOGERN WEIR

Excavation of the canal is accomplished by steam shovels and clam-shell excavators. The rock is blasted by liquid air. The power house foundation has to be carried down through 60 ft. of waterbearing gravel to solid rock. The upstream front and the two side walls were first put down with compressed air on concrete caissons of 35 ft. width, the down-stream side was closed by steel sheet piling. Thus the power house area was closed off on all four sides from the groundwater and the substructure of the three units can be built between these walls practically without any pumping.

The cost of the total development is estimated at $13,000,000, that is $160 per kw. installed.

The design and supervision of the development is provided by Dr. H. E. Gruner, Bale, consulting engineer, M. Am. Soc. C. E. The turbines are furnished by Escher, Wyss & Cie, Zürich. Construction was let to the following firms: Weir and entrance structure to Locher & Cie, Zürich, canal and power house to Hochtief, Essen and Butzer, Dortmund.

Cavitation

OUR ATTENTION has been directed to a typographical error in the article on cavitation which appeared on page 674 of our September issue. At the end of the first paragraph of this article reference is made to N.E.L.A. Publication No. 122. This reference should have been Publication No. 222.

Hydraulic Plant Outage

SUMMARIZING causes for outage of hydraulic generating units for 1930, the report of the Hydraulic Power Committee of N. E. L. A. gives figures which are of interest as indicating the points at which special attention may well be given. Records used were for 230 units in 113 plants, the sizes running from 7500 to 70,000 hp. with average of 24,858 hp. Most of the units were from 10,000 to 40,000 hp. They were divided as follows: Vertical reaction, 186 units, average 25,000 hp.; horizontal reaction, 5 units, average 15,620 hp.; impulse, 26 units, average 25,680 hp.; propeller, 13 units, average 24,300 hp. For reaction and propeller types the head was from 47 to 861 ft. and for impulse type from 930 to 2563 ft. Speeds were from 75 to 600 r.p.m.

Of the 113 plants, 66 had no outage during demand time when they were needed for service, four having no outage whatever. As a percentage, outage during demand time shows slight increase over an 11-yr. period with years in service, the increase being 0.098 per cent a year from time of installation starting at 0.27 per cent; increase per year of operation was 0.049 per cent, starting from 0.56 per cent in the second year of operation because getting out starting up kinks is the cause of considerable outage the first year.

Outage Causes for Hydraulic Units, Per Cent of Total Outage Time

	TYPE OF UNIT				
			Reaction		
	Prop'l'r.	Impulse	Hor.	Vert.	Total
No. of Units	13	26	5	186	230
CAUSES					
General Hydraulic					
Ice or Trash	1.4	-	-	0.4	0.5
Penstock or Canal	0.1	16.1	45.5	1.9	3.7
Head Gates or Intake	0.4	0.2	-	2.1	1.6
Other General	-	-	-	0.3	0.3
Total	1.9	16.3	45.5	4.7	6.1
Water Wheels and Auxil.					
Runners	5.9	36.4	-	19.3	18.8
Shut-off Valves	-	1.5	-	0.9	0.8
Gates and Needle Nozzle	-	4.6	-	1.8	1.8
Guide & Main Bearings	14.7	1.4	-	3.9	5.3
Thrust Bearings	-	-	-	2.1	1.5
Governing System	2.3	0.8	5.2	4.0	3.4
Pressure Reg. or Deflectors	-	1.2	-	0.6	0.6
Draft Tube	13.4	-	-	3.8	4.8
Lubrication System	0.5	-	4.2	1.3	1.0
Vibration	-	-	-	0.1	0.1
Seal Rings	-	-	1.1	-	0.1
Inspection	0.9	5.6	2.1	6.0	5.1
Overhauling & Replacement	55.3	8.7	15.2	10.3	17.2
Other Causes	0.2	0.9	-	2.3	1.8
Total	93.2	61.1	27.8	56.4	62.3
Generator System					
Vibration	-	0.5	-	0.5	0.4
Lubrication System	-	-	-	1.0	0.7
Rotor or Field	0.6	12.2	8.5	5.1	5.3
Armature Core or Windings	-	2.1	-	9.3	6.9
Exciter System	0.5	0.9	1.1	2.3	1.8
Ventilation System	-	-	-	1.0	0.7
Cleaning	1.5	2.8	12.7	9.7	7.7
Inspection	1.9	2.8	1.2	4.2	3.7
Other Causes	0.4	1.3	3.2	5.8	4.4
Total	4.9	22.6	26.7	38.9	31.6
Total, All Causes	100	100	100	100	100
Total Outage % Total Time	10.58	3.77	2.03	3.46	3.87
Outage Time When in Demand	0.03	0.37	0.03	0.33	0.31
Max. Possible Service Time	89.42	96.23	97.97	96.25	95.89
Demand Availability Factor	99.96	99.78	99.97	99.48	99.55

Various outages are shown in the table.

Other items, appearing in the details of the report for individual units are: Bronze sleeve on wheel shaft and overhauling governing system, 15.6 per cent; reconstruction of turbine 10.8 per cent; rebucketing, 12.5 per cent; new throat ring and draft tube liner, 15.8 per cent; replacing cast-iron throat ring with welded steel, 28.4 per cent; replacing armature iron and windings, 36.6 per cent.

Operation and Economy of Diesel Stations

MAJORITY OF DIESEL PLANTS ARE OPERATING FAR BELOW PAR AND REQUIRE BETTER SUPERVISION. BOILER FUEL OIL SHOULD CUT FUEL COSTS. BY H. W. STALNAKER*

WHEN WE LOOK OVER the operating-cost records of Diesel engine driven generating stations there can be but little doubt of the vital necessity for cheaper Diesel fuel oils and more efficient operating methods. Indeed, unless some such changes are made in the near future, the Diesel engine manufacturers are going to find some of the most fertile fields closed to the use of their engines.

In the eastern part of the United States, where the so-called good Diesel fuel oil costs 5.5 to 6c per gal. the three largest and most modern Diesel plants are all municipal owned. Their generating costs are 8.20, 10.29, and 13.86 mills. None of these generating costs are in line with what it costs to generate a kilowatt hour in the modern central station steam plant; neither are they in line with what it costs to generate a kilowatt hour in a modern Diesel plant where the cost of fuel oil is more reasonable. Such generating costs, when fixed charges and distribution costs are added, are prohibitive. For the latter reason many of the larger electrical utility companies, particularly in the East, refuse even to consider the operation of Diesel engines except for standby service.

This paper is intended to show that Diesel plant operation can be improved and that the present more or less closed fields for Diesel engine installation can be opened up. While the paper contains many positive statements of a highly controversial nature, they reflect actual experience of the author while in the employ of one of the large electrical utility companies and while using the heaviest of boiler fuel oils as Diesel fuel.

FUEL AND LABOR MAKE HIGH COSTS

Two chief reasons for high generating costs in Diesel driven generating stations are the high cost of so called good Diesel fuel and the employment of unskilled supervisors. To unskilled supervision can also be attributed low thermal efficiency, high maintenance costs and high fixed charges, the latter on account of the necessity for installing standby generating capacity to take care of service in case of mechanical failures.

In the Eastern part of the United States Diesel fuel oil that will meet the specifications of the Diesel engine manufacturers costs about 40 ct. per 1,000,000 B.t.u., while the best qualities of steam coal cost but 8 ct. per 1,000,000 B.t.u. In other words, the Diesel operator must pay about five times as much for fuel as the steam plant pays. Then consider what the difference in thermal efficiency is between steam and Diesel plants.

A few years ago about 30,000 B.t.u. was required to produce 1 kw-hr. in the central station steam plants and the Diesel plant of even small size required but 12,000 B.t.u. for the same work. Today the modern central station steam plant of even medium size requires but 15,000 B.t.u. and in some cases even less. On the other hand, the Diesel plant of even the largest size remains at 12,000 B.t.u. per kw-hr. in even the most efficiently operated plants. In other words, while the efficiency of the steam plant has been increased by more than 100 per cent, the Diesel has remained at a standstill.

CHEAPER OIL IMPERATIVE

In view of these facts, it begins to look as though it will be but a short time until the steam plant will have surpassed the Diesel in thermal efficiency, just as it already in many cases has surpassed it in overall economy. Such being the case, it is quite obvious that a centrally located steam plant of, say 25,000 kw. capacity can supply electrical energy to two or more small cities far cheaper than it can be produced in Diesel driven municipal-owned plants operating at the present high generating cost.

Even in view of these startling facts the Diesel manufacturers are reluctant to turn to the cheaper boiler fuels as a possible means of bettering conditions. They still seem to think that they can further reduce overall generating costs by lower initial cost per horsepower and can lower labor costs by practically automatic operation. Again referring to fuel oil, the Diesel manufacturers are even unable to agree on any one standard specification, but rather each Diesel manufacturer has his own specification and insists that his engines be operated on fuel of such characteristics, otherwise he washes his hands of any troubles that may develop.

So far but one manufacturer of Diesel engines has shown any inclination toward very broad specifications. His specification is, "Our engines will operate on any commercial fuel oil or crude produced in the United States or Mexico." It is clear that such broad specifications if adopted by the rest of the Diesel industry would go a long way toward lowering the cost. In other words, the manufacturers of Diesel engines have built an engine and expect the oil companies to produce a fuel to operate it with.

Why not the other way around? Build an engine with an injection system that will operate efficiently on the fuel oils that the oil companies at present produce. There are quite a few slow speed, heavy duty engines that will handle the heavier fuel oils with but few changes, all of a minor nature; however, as previously mentioned, these same manufacturers are slow to take advantage of the cheaper fuel oils.

Take the residual fuel oils from the low-pressure stills: These residues are all pumped to the same storage tanks and the resulting mixture is marketed as Bunker C. This fuel, which is almost a drug on the market, due to the ever increasing use of pulverized coal in the large steam stations, can be purchased for about one-half of what the lighter fuel oils sell for. Bunker C, when properly prepared by passing it through a centrifuge and when heated to give the desired viscosity, makes a very suitable fuel for slow speed, heavy duty air or mechanical injection Diesel engines. Such engines will operate efficiently, with 100 per cent reliability and with very low overall generating costs on such fuel oils.

Before making any attempt to burn boiler fuel oil

*From a paper presented before the A. S. M. E.

in Diesel engines—provided the engine is of a type that will handle the boiler fuel oil efficiently, the following provisions should be made:

A capable Diesel engineer should be employed of a little higher caliber than usually found in the average Diesel plant. He should have at least a high school education and preferably a technical education. He should have a record of being able to obtain the highest possible efficiencies when operating Diesel engines on the lighter fuel oils. In other words, he should be able to make the engines live up to the manufacturer's guarantee or better. Any engineer that operates a Diesel plant and gets but 11 kw. hr. per gal. of fuel, when he should get 12, certainly should not be trusted to operate a plant on boiler fuel. He should also be a first class machinist and able to do all maintenance and repair work, regardless of its nature. Unless a man with such characteristics is employed, it will usually be found that the heavy fuel project is a failure even before the first car of heavy fuel oil arrives at the plant.

Compression to 525 Lb.

It is important that a Diesel engine have plenty of excess air for any type of fuel oil. It is far more important that it have a very large excess when it is to operate on boiler fuel oil. Of course, the amount of excess air is to a great extent regulated by the factory air inlet valve settings. However, in many cases air filters are installed, and often they are too small or perhaps not kept clean. Or perhaps new timing gears have been installed and the air inlet valve settings are not the same as the original setting. Or, again, it may be that the original factory setting was not correct. In two cycle engines the scavenging pressure may have to be increased or the exhaust ports may be fouled with carbon. There are many factors that may have a large effect on the amount of air drawn into the cylinder.

Compression of the engine should be raised to not less than 525 lb. per sq. in. (by inserting shims under the foot of the connecting rod). Two piece piston rings should be installed in the third and fourth grooves of the piston to prevent the corrosive exhaust gases (caused by sulphur in boiler fuel) from blowing by into the crankcase. In no case should two piece piston rings be installed in the top two grooves as they will cause very rapid wear (stepping) of the lands on the piston.

A pyrometer should be installed. This is important with solid injection type engines. An indicator must be provided but it is usually unnecessary to provide an indicator motion, since the fuel valve settings will be much more clearly shown on an out of phase or hand drawn card. If the engine does not perform as well or better on the heavy fuel than it did on the lighter fuel oils, then an indicator motion should be installed and phase cards taken to locate the trouble. Sometimes it is necessary to provide burner plates or spray nozzles with slightly larger holes. It also may be necessary to respace the atomizer disks. Of course none of this can be done to any set rule but must be determined from the indicator cards taken after the engine is in operation on the heavy fuel oil.

Next we come to the necessity of cleaning and heating the boiler fuel oil. Nearly all of the commercial fuel oils reach the same viscosity around 200 to 225 deg. F. and by raising the temperature of the boiler fuel, light fuel oil viscosity can be duplicated. In nearly all of the heavy duty, slow speed engines the best operating viscosity is usually between 50 and 75 sec. Saybolt, and nearly all of the commercial boiler fuel oils will reach this viscosity well below 200 deg. F. Even much higher temperatures are well below the flash and carbonization points.

Best operating temperature for any engine can be found by actual operation. Separate fuel tanks or accurately calibrated meters must be provided for each engine and the fuel consumption checked each 24 hr. Any change in rate of consumption should immediately be investigated. It is well to remember that the products of poor combustion are very abrasive, and they are even more so with boiler fuel than with the lighter fuel oils, and that poor combustion is responsible for rapid cylinder liner and piston ring wear.

Supervisory Service

Plants of fair size can afford to employ the services of engineers capable of producing the desired results. For small plants that cannot, even if there were enough good Diesel men to go around, it would seem that there is a good field for "supervisory engineering companies" to investigate, with a view of profit to themselves, operating on a percentage of the net savings made in each case. Or probably even better still would it be for the manufacturers of Diesel equipment to retain supervisory control over the smaller plants until such time as the operating force can show that they are capable of commercial and reliable operation.

Diesel engine manufacturers, with their branch offices in all of the larger cities, should easily be able to operate such a service and not only better the entire Diesel industry but show a profit to themselves. Of course it would be necessary for them to employ engineers of a different caliber than the usual factory erection engineers. These should be men of the same caliber as the master mechanics of the large pipe line companies or men such as the superintendents of Diesel power for the large electrical utility companies. Men that are capable of looking at the overall cost per kilowatt hour and not just the kind that says, "This cylinder liner shows lots of wear and you had better change your quality of fuel or lubricating oil and buy several hundred dollars' worth of spare parts to repair the engine."

Whether or not supervisory control is to be used, it is obvious that much improvement in operation is necessary and is possible.

In the National Exposition of Power and Mechanical Engineering to be held in Grand Central Palace, New York, Dec. 5 to 10, reports from exhibitors indicate that the research of the past 2 yr. and the results embodied in new and improved products will lend great interest and novelty to the displays.

Automatic control, which has made marked progress, will occupy an important place, including electric temperature control and record of temperatures of fast-moving objects. Water-level indicators, high and low-water alarms, steam traps, expansion joints and pipe fittings of improved design will be exhibited.

The activity of the national committee on modernization of plant facilities, which is actively at work under the chairmanship of A. W. Robertson of Pittsburgh dovetails well for engineers with the opportunity to see at the National Power Show the equipment which will fit into a modernization program for their plants.

Readers' Conference

Experiences with Cavitation

PERMIT ME TO OFFER my congratulations on your very excellent judgment in publishing Prof. Spannhake's paper on cavitation in the Sept. Power Plant Engineering.

There is so little known about this subject and has been so little printed that it is most encouraging to find someone actually going into details.

The layman has absolutely no conception of its causes but of course can see its results if he happens to get cavitation in some of his centrifugals. Engineers recognize cavitation when they see it but the number who know how to go about eliminating it is woefully small. After all, eliminating cavitation after it shows up, in spite of preliminary design, is the engineer's principal job; the forces set up in action by cavitation may be what they will as long as it can be finally eliminated.

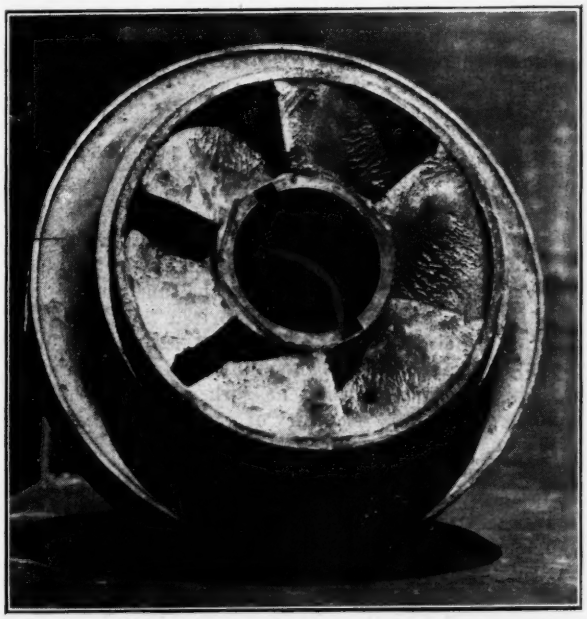


FIG. 1. CAVITATION ON AN IMPELLER FROM A CENTRIFUGAL PUMP AFTER BEING IN SERVICE LESS THAN 90 DAYS

In Fig. 1 is shown a photograph of an impeller taken from a centrifugal pump. This shows cavitation at its worst as far as my acquaintance with it is concerned. The impeller shown was in service less than 90 days and if my memory is correct the actual service was not more than 30 days. It was in a 400 ft. head, 3600 r.p.m., single stage pump with a positive suction of about 10 ft. Pump was steam turbine driven and installed in 1919. After two impellers were worn through in about the same time each, I had a pattern made for the impeller and changed the entering angle to what in my judgment should eliminate cavitation. The resulting impeller gave no more trouble and we obtained the expected life from it. Of course luck was with us, but in this case Prof. Spannhake's claim that cavitation is more physical than chemical was convincingly illustrated.

We all know that due to its construction the inside of a closed impeller cannot be perfect and this fact alone may be enough to start cavitation. Manufacturers of speed boat propellers within the past year have been trying to educate the boating public in the value of maintaining a true uniformity of pitch, an absolutely

FIG. 2. PITTING OF THE CAST IRON BLADES OF THE IMPELLER USED IN VACUUM PANS IN THE SALT INDUSTRY

accurate balance and the use of distortionless material in their propellers. We, of course, always assume that a propeller should be in balance but do not appreciate the increase in efficiency due to true uniformity of pitch or the use of distortionless material, both conditions which tend to eliminate cavitation. Naturally the ordinary speed boat propeller goes into discard from abuse rather than use so that very little concrete evidence of the results of cavitation can be found in this field.

We know also that if a high speed engine and small wheel are put in a heavy boat, very little headway can be made due to cavitation yet the same engine with a reduction gear and large wheel will perform as expected. These same conditions apply to the propeller type hydraulic turbine. Here, however, the number of hours of operation permit the results of cavitation to be plainly seen. The load carried will probably govern the results of cavitation to a certain extent.

Figures 2, 3 and 4 are photographs of the cast iron blades of impellers used in vacuum pans in the salt industry. They make from 40-60 r.p.m. The large blades shown in Fig. 2 form an impeller 8 ft. 4 in. in diameter. Those shown in Figs. 3 and 4 are slightly smaller. The blades shown in Fig. 2 have had the holes filled in several years ago as can easily be seen but have since pitted further alongside the original holes. The pitting of the blades in Figs. 3 and 4 is very plain. I do not know exactly how long these blades were in operation. It must be remembered that a coating of scale builds up on these blades which fact tends to protect them until the blades are scaled.

Some years ago while checking the friction loss

through a 60 in. check valve, in an endeavor to find out why the disks were being ripped off and carried up the pump discharge line, at a certain rating the manometer reversed and as the rating changed further the manometer reversed further. The test was re-run and the manometer reversed at a certain point as before. As the check was next to a 60 in. quarter bend it was plainly evident that the water was crowding through the outside ports of the check, the inside ports being closed, and that

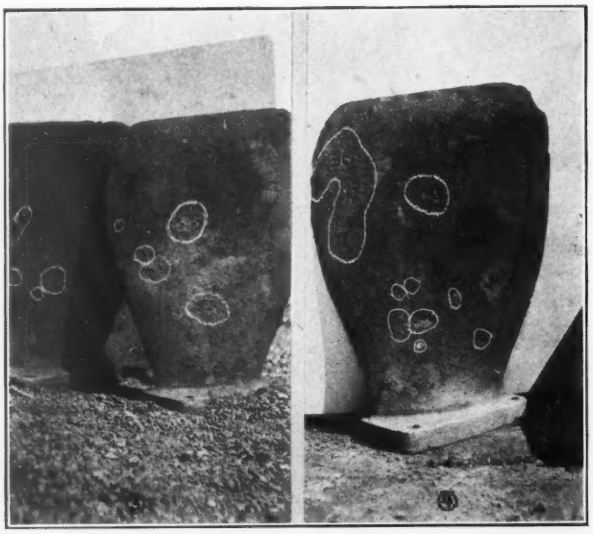


FIG. 3 AND 4. OTHER EXAMPLES OF PITTING OF IMPELLER BLADES DUE TO CAVITATION

cavitation was occurring at the inside of the elbow. Trouble was eliminated by limiting the travel of all checks. No pitting was found on the inside of the elbow due probably to the limited time the condition had existed.

Prof. Spannhake gives a formula for comparative results of cavitation but it would be interesting if the actual weight of the blows could be calculated in foot pounds.

Cleveland, O. J. N. H. CHRISTMAN.

Driving Conveyor Belt Idlers by Motors

ON PAGE 683 OF the "Readers' Conference" in Power Plant Engineering for September, 1932, W. E. Warner refers to motors used for driving the idler pulleys of belt conveyors, thus assisting the main drive motor which drives the head pulley. I assume these are a.c. motors and that squirrel cage induction motors are used. Since an induction motor has a certain amount of slip and since this slip increases with increase in load, I am curious to know if any precaution is taken to get the motors to run at exactly the same speed and divide the load properly. Undoubtedly the head pulley motor is considerably larger than the motors driving the idler pulleys, so that the speed-torque curves of the small idler motors would have to matched up with the speed torque curve of a much larger rating. Motors driving the idler pulleys must of necessity be of rather small capacity since they are required to drive only every second or third idler. I assume that the horsepower of each idler motor is figured for carrying the load caused by one idler plus its share of the belt on the basis that its per cent slip is the same as the motor driving the head pulley. Now it is well known that even two motors of identical rating do not always have identical speed torque curves and if one of the small idler pulley motors had less slip than the large head pulley motor, it would be compelled to run at a lower speed than required for driving its share of the load and would thus take more than its share of the load. Under these conditions if it had torque enough or if there was insufficient friction between the idler pulley and the belt, it might tend to drive the idler faster than the belt and cause unnecessary belt wear.

This scheme of dividing the strain on a long conveyor belt by applying motors at various points along the conveyor is very interesting since it makes possible the use of longer conveyor belts as well as reducing the strength and size required of the belt and the component parts.

Schenectady, N. Y. R. F. EMERSON.

Why Did Polarity of Large Generator Reverse?

ON PAGE 606 of August 1 issue there appeared a question as to why the polarity of a generator reversed. The most common way in which the field of a direct current generator can lose its residual magnetism is to have a magnetic flux of polarity opposite to that of the residual magnetism and strong enough to neutralize it applied to the field poles from an external source. A higher or prolonged value of the flux will reverse the residual magnetism.

Probably the source of the external flux is the flux produced by the series field. While it is of the same polarity as the shunt field flux when the generator is carrying load, it is of opposite polarity on a reversal of current through both the armature and series field when the generator is motorized. During the time the machine is acting as a generator or is motorized the shunt field polarity remains the same. The series field being wound directly over the shunt field and both being placed on the same poles, the former has, when the generator is motorized, a good opportunity of neutralizing the latter.

The cause of the motorization of the large generator is found in the method by which its load current is reduced to allow its knife switch to be opened. It is likely that the load of the large generator is not reduced by the opening of circuit breaking devices at the loads but by the lowering of its voltage until the armature current is small. When the voltage is lowered, the motors supplied by the generator will reduce their speed but if they are driving high-inertia loads, such as those having flywheels, heavy rotating parts or much line shafting, they will not fall off in speed in proportion. They will continue to rotate at comparatively high speed and thus act as generators sending current to the Corliss engine driven generator and tending to make the latter run as a motor. If the voltage is reduced too rapidly, a high surge of current will flow through the generator's series field and armature, the series field will produce a flux of polarity opposite to that made by the shunt field and the poles will have their residual magnetism neutralized or reversed as explained. The loads of high inertia are running, it is probable, only in the day time and, therefore, this condition does not exist when the changeover is made from the small generator to the large one.

This action will take place, also, if the speed of the

large engine is suddenly reduced while its generator is carrying load. If the small engine is started while the large one is carrying near full load, the steam pressure might fall and cause a sudden drop in speed of the latter. The result would be a quick lowering of its voltage, and therefore, the residual magnetism would be reversed.

All this is true in the case where a double-throw switch is used. In the case of the use of the two single-throw switches, one for each generator, the same action will take place if the load on the large generator is reduced by lowering its voltage before the knife switch for the small generator is closed.

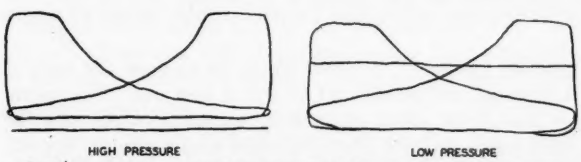
Hammond, Indiana. S. EIN.

Compression in Engines

REMARKS on page 638 by Charles J. Mason warrant a close study by most operators. Unquestionably compression is carried higher than necessary by most engineers because of the popular conception of a perfect card with well rounded corners. High compression reduces the card area or engine output and also the efficiency. This is one point where theory and practice do not exactly agree due to unforseen and hidden losses. There are initial condensation losses which increase with the clearance volume but this clearance loss can theoretically be eliminated if compression is carried up as high as the initial pressure although the output of the engine is decreased.

Unfortunately this initial loss is not so easily eliminated in practice. If a Corliss engine with compression to the initial pressure has the compression reduced, the efficiency will increase to a certain point and then begin to decrease again as the point where there is no compression is reached. The point of best efficiency is when the beginning of compression is at about 1.75 to 2.25 times the clearance volume. Apparently with higher compression, leakage losses more than balance decreased condensation loss. This must apply to uniflows as well as Corliss engines because the efficiency of the former can be increased materially by using auxiliary exhaust valves which in effect simply cuts down the compression.

I have always felt that compression should be carried



CARDS FROM A CROSS COMPOUND CORLISS ENGINE SHOWING LOW COMPRESSION ON BOTH CYLINDERS

as low as consistent with smooth operation of the engine in question. This will vary with the type, size and speed of the engine. This low compression is shown by the attached cards taken from a cross compound engine overhauled some years ago. Some engines will operate smoothly on less compression than others and this depends somewhat on the lead as well. Some engineers like early admission to heat up the cylinder as soon as possible while others favor later admission feeling that pressure exerted during the early part of the stroke simply causes high pin and bearing pressures without doing much useful work. Perhaps the best is a middle course with just sufficient lead to insure the valve opening while the piston is practically still.

With moderate pressures, changes from condensing to noncondensing operation can be made without changing eccentrics if the range of cutoff or load can be controlled reasonably well but with early cutoff, that is light load, loops in the lower ends of the cards cannot be avoided and will usually cause the valves to slam or pound. Excessive receiver pressure is another element of actual danger with manually operated low pressure cylinder cutoff. If the engine is loaded up, naturally the high pressure cutoff will lengthen and the receiver pressure go up. If the change from condensing to noncondensing takes place often, the pop valve will probably give sufficient protection because it will be looked after. Usually however the relief valves on the receiver and cylinder will not operate and you'll find them filled with dirt and grease. The high pressure cylinder will take all or as much of the load as it can carry and tend to cause unbalance of the unit.

During normal operating conditions with usual pressure the average cross compound receiver pressure will not be much above atmosphere and the receivers and low pressure cylinders are not built to stand pressures which may be built up in emergencies. P. F. ROGERS.

Brooklyn, N. Y.

Pipe Covering to Prevent Sweating

W. F. SCHAPHORST made a statement on page 683 of the September issue which should not be allowed to pass without comment as it might well mislead readers and cause them to purchase expensive pipe covering.

Under ordinary conditions, I have covered many thousand feet of cold water pipe where the temperature of the water in the pipes varied from 35 to 50 deg. F. and the outside air temperature was from 60 to 75 deg. and at no time did enough sweating occur to saturate the covering and drip condensation.

To prevent a cold water pipe from sweating, the main requirement is to prevent the higher temperature air, moist or otherwise, from coming into contact with the surface of the cold pipe. The method I followed successfully is given herewith.

The flow of the water through the pipe was cut off and, when the surface of the outside of the pipe became dry, strips of heavy wrapping paper, 2 in. wide, easily formed into rolls, like friction tape by sawing slices off the end of stock rolls for easy handling, was tightly wound spirally and slightly overlapping around the pipe from end to end. The fittings were covered in the same manner with narrower strips. All ends and breaks in the strips were fastened down with adhesive. The whole surface was then given a coat of common whiting mixed about as thick as paint with paint oil. When this was dry, strips of common burlap were wound over the paper and given a coat of the whiting paint and allowed to dry. Then a second covering of the cloth was applied and painted. When dry all was given a finishing coat of good water-proof paint.

Cost is extremely small for material. Under temperature conditions I have named, cold water pipes so treated did not sweat enough to drip. Unless the covering is made almost air tight it will not prove satisfactory. Some condensation formed, in a few cases, on the surface of the covering but not in such quantity as to cause damage from dripping.

Toronto, Can. JAMES E. NOBLE.

Experiences in Heating Plant Operation

Our heating plant consists of five 612-hp. Stirling boilers equipped with Detrick arches and Coxe stokers. The fuel used is No. 3 anthracite buckwheat. The pressure carried is 175 lb. gage and operating four boilers at from 175 to 200 per cent of rating leaves one spare boiler.

One of the early troubles experienced was the failure of fusible plugs. To check up on this trouble a thermo-couple was inserted in the fire side of the fuse metal, also in the boiler shell adjacent to the plug. Within 30 min. after the boiler was brought up to 200 per cent of rating the pyrometer registered the melting point of the fuse metal and the thermo-couple detached itself from the fuse metal. Higher temperature fuse plugs were then substituted and former trouble was practically overcome.

Past experience with fusible plugs indicates that they are unreliable under some conditions. Upon removing some of the plugs after a comparatively short time the fuse metal was found to be entirely replaced by scale and other foreign matter which would not fuse at temperatures which would prove fatal to the boilers.

During a hard coal miners' strike, No. 1 buckwheat was substituted for the No. 3. This worked well at 150 per cent rating but at 175 to 200 per cent, secondary combustion was present in the uptake. If the air supply was adjusted to overcome the secondary combustion we lost our ignition. With No. 1 buckwheat, however, there was no fuel in the refuse, the ash being discharged as fused clinker. These conditions offset each other and the evaporation was practically the same as with No. 3 buckwheat.

With No. 1 buckwheat the grate bars began to warp. Instead of becoming black on the top as with No. 3 Buckwheat, the banked fires remained a dull red with short gas flames playing over the surface. It was soon discovered, by observing the grates through the cleanout doors, that with banked fires the grates became dark red. This was overcome by opening up doors in the setting which would kill the draft over the fire causing the No. 1 buckwheat banked fire to become black as with No. 3.

When the supply of No. 1 buckwheat was exhausted, coke breeze was successfully burned. The principal difficulty with coke breeze developed in the main bearings of the single acting stoker engines. The breathing of the engines drew the fine coke dust into these bearings and between shutting down for cleaning boilers, some of the bearing bushings would be ground entirely through to the casting.

Feedwater trouble developed on one of the boilers. Whenever the boiler operated at 200 per cent rating it would lose its water. Under such conditions it was noted that the gage pressure increased. This led to examination of the dry pipe, the holes in which were found to be partly plugged with scale. Later it was found that similar trouble occurred with any of the boilers when the ratings were increased much above 200 per cent and as the combined area of the holes in the dry pipes only approximated half the area of the 6-in. pipes between boilers and headers, the number of holes was increased 50 per cent.

About 80 per cent of the feedwater is made up of returns from the heating system. The other 20 per cent contains very little scale forming material. The boilers, therefore, go through the entire season with but one general cleaning. After evaporating from 30,000,000 to 35,000,000 lb. in a boiler, however, it is necessary to take it off the line and clean the three rows of tubes through which the feedwater makes its first pass down to the mud drum, as considerable mud bakes on these tubes.

On the fire side of the tubes, a scale condition exists which to date has not been satisfactorily solved. This consists of a slag scale from 1/64 to 1/8 in. thick deposited over much of the tube surface especially in the second and third pass. The scale has the general appearance of a hard water scale and is difficult to remove.

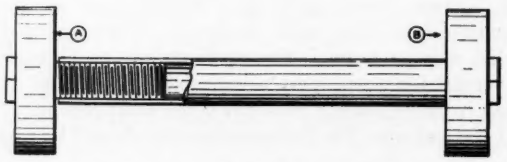
Some trouble with pitting was caused by the warping of the feed pans. Where the pans came in contact with the shell, pitting occurred. In one place a space as large as a man's hand was a mass of pits having the appearance of a sponge. As there has been no other pitting it is quite apparent that in some way the contact of the feed pan and boiler shell formed a local cell. At present bands of trolley wire have been installed between the shell and the feed pans to prevent a possible reoccurrence of the difficulty.

Ithaca, N. Y. H. A. Ward.

Pump Valve Balked

Illustrated herewith is the main steam valve of a pump which had operated for years but suddenly moved the piston to one end of the cylinder and could not be made to return it by any of the usual methods known to the operator.

As illustrated, the valve is made in two parts, A and B. Part A has a shorter sleeve which is threaded male and B a long sleeve threaded female. When screwed



UNSCREWING OF VALVE PARTS CAUSED PUMP FAILURE

together properly, B sleeve butts up against the part of A forming the piston and acts as a lock nut. The operator had tried about everything except looking into the main valve and was about to order a new pump. Investigation, however, showed that A had screwed out of B as far as the heads on the ends of the cylinder would allow, making it impossible for the valve to move even when the pilot or auxiliary valve was moved by hand. After putting it together again, the operator said that it had never run better. Fred S. Rutledge.

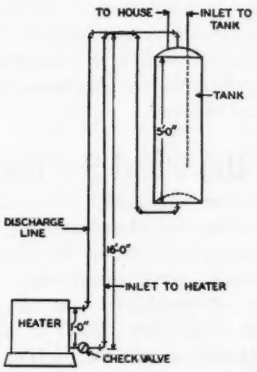
Minneapolis, Minn.

U. S. Civil Service Commission sends out warning that paying for coaching courses for federal civil service examinations is at the present time a waste of money since few appointments are being made and vacancies are filled by transfer of those in service and reinstatement of those who have been in service, whenever practicable. Also large rosters of eligibles from past examinations are available if new employes are needed.

Plant Operation Problems

What Caused Reversed Flow?

IN THE accompanying sketch is shown an arrangement of a small hot water installation. Due to structural obstruction, the cold water inlet line to the heater was raised to the same height as the discharge line. When starting up it was found that as soon as the water became warm, the flow in the pipes reversed and the hot water entered the bottom of the tank through the inlet



HEATER CONNECTIONS THAT CAUSED REVERSED FLOW

pipe. To bring the hot water in at the top of the tank it was necessary to install a check valve in the inlet pipe, as indicated in the sketch.

What caused the flow to reverse itself? E. W.

Readers are invited to submit their solutions to this problem. EDITOR.

Ammonia Plant Kinks

Q. 1. We are losing a great deal of ammonia and would like to know how to test for leakage?

2. After one side of the system has been pumped out and air admitted to it what is the proper way to put it back in service? P. F. B.

A. 1. If the leak is under water you can test with litmus paper which can be purchased at any drug store. If the leak is not under water the most satisfactory method is to use a sulphur candle. This may be purchased or can be made by melting sulphur and pouring it into a mold into which a piece of candle wick is suspended. The sulphur burns with an almost colorless flame but when it comes in contact with the ammonia a dense white smoke appears.

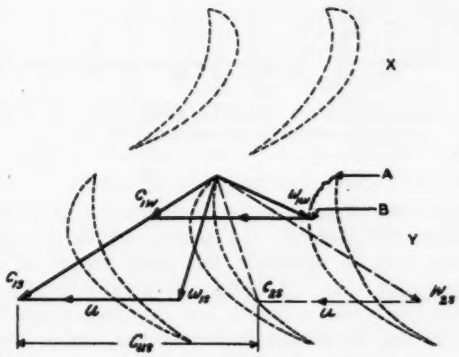
2. After one side of the system has been opened and air admitted, the air should be pumped out to a vacuum of at least 25 in. before the ammonia is admitted. The ammonia should be let in at the farthest valve so that it will drive the remaining air ahead of it as it comes up to the compressor. The purge valve should be left open all during this time and when the ammonia appears at this valve, the air will be very nearly eliminated from the system.

Erosion of Steam Turbine Blades

In photographs and descriptions of turbine blades showing erosion, the worn area is usually on the back of the blade. Inasmuch as the steam velocity must be higher than the blade velocity, it seems to me the impact and wear should be on the front of the blade. What causes the erosion on the back of these parts? A. M.

A. Erosion is caused by moisture drops in the last stages of the turbine and comes about because these moisture particles do not maintain the same velocity as the steam which carries them. This was explained in considerable detail in a paper, "Problems in Steam Turbine Design" by C. R. Hogerberg of the Westinghouse Electric & Manufacturing Co. This paper was abstracted on page 526 of the July 1, 1932, issue of Power Plant Engineering.

Referring to the drawing, the steam leaves the stationary row X and enters the rotating row Y with the



BLADE EROSION AS CAUSED BY THE IMPINGING OF WATER PARTICLES ON THE BACK OF THE BLADE

absolute velocity c_{1s}, and the relative velocity w_{1s}. It expands in the rotating row to the relative velocity w_{2s} and the absolute velocity c_{2s} so that the change in momentum for a unit mass of steam is c_{us}. The moisture, at the moment of precipitation, has the velocity of the steam c_{1s}, but the drops immediately begin to be retarded and they enter the rotating row with a velocity c_{1w} which is less than c_{1s}. The relative velocity of this water is w_{1w}, the velocity by which the water drops will impinge on the blade.

The serious consequence of the retardation of this water is the erosion of the back of the rotating row Y. The eroded portion will extend from A to B with the most intensive erosion at A. The amount of erosion is a function of both the degree of moisture and the impinging velocity. Presumably, the size of the drops and the pressure also enter into the phenomenon but the actual relationship is not very well understood as yet. This erosion is at the present time the chief factor in limiting the peripheral speed and thus the exhaust annulus, of large turbines.

Metals at High Temperatures

It is the writer's understanding that steel plate and tubing are considerably weakened by being subjected to temperatures exceeding 750 deg. F. Steam boilers are now in use with pressures up to 1200 lb. per sq. in. and temperatures up to 850 deg. F., with superheaters subjected to temperatures of 950 deg. F. Will you kindly explain why these steel plates and tubes are able to withstand, without failure, these high temperatures and pressures? M. A. E.

A. Your understanding of the effect of temperature on metal is correct. The exact temperature at which the strength of the plate, or tube, begins to decrease depends upon the chemical composition of the metal itself, upon the annealing and upon the amount of cold or hot working which it has received. The point of maximum tensile strength ranges from 400 up to about 800 deg. F.

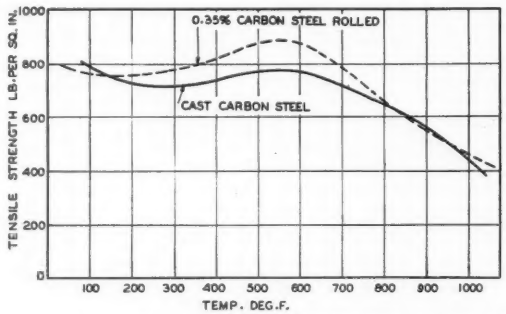


FIG. 1. VARIATION OF TENSILE STRENGTH OF TWO DIFFERENT STEELS WITH TEMPERATURE

Figure 1 shows the variation of tensile strength of two different steels as the temperature is increased. At about 600 deg. F. the tensile strength begins to decrease and to maintain the same factor of safety lower stresses, that is, larger cross-sections must be used. It is not the tensile strength but the creep characteristic which is the important factor at the higher temperatures, creep being the tendency to increase in length slowly when under stress.

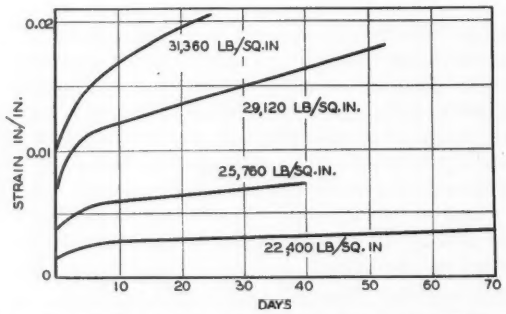


FIG. 2. RESULTS OF CREEP TESTS ON A 0.30 PER CENT CARBON CAST STEEL AT 780 DEG. F.

This is shown by Fig. 2 for a cast steel at about 780 deg. F. At a stress of about 25,000 lb. per sq. in. the specimen increased one per cent in length in about 100 da. At a lower stress of about 22,000 lb. an increase of one per cent in length would take about 2 yr. Both the creep value and tensile strength must be taken into consideration by the designer. Alloy steels have better characteristics than plain carbon steels but are much more expensive so that in many cases the value of higher temperatures does not warrant the added expense.

Up to a year or so ago, 750 deg. F. was generally considered the maximum safe working temperature, although 825 and 850 and even 1100 deg. is now being used, with demands for superheater elements suitable for a metal temperature of 1300 deg. F. Of course, in 1200-lb. boilers, the boiler drum and boiler tubes and water walls are subjected to a temperature of only about 570 deg. F. Even at the critical pressure of 3226 lb. the saturated steam temperature is only 706 deg. F. Superheaters are subjected to higher temperatures, as mentioned above, and the elements must be made correspondingly heavy, so that the stress is low.

This matter is discussed in considerable detail in an article, Radiant Superheater Developments on page 128 of our February 1, 1932, issue. As much as a 37 per cent increase in circumference without failure occurred in certain of these superheater elements before failure. Under these conditions, the pressure stresses were 6.4 times the original stresses.

When the Field Switch Opens

HAVING READ the various articles that have recently appeared concerning the above subject, I would like to submit the following account of an experience I had in one of the old-time power plants about 23 yr. ago.

The hook-up of machines was as follows: In one plant there was a 115 kw., 2300 v. alternator driven by water wheels and a 300 kw. driven by a Diesel oil engine running in parallel. About 18 miles distant there was a 50 kw., 11,000 v. alternator feeding into the main bus of the first station through a step-down transformer.

One day when this arrangement was operating smoothly the voltage was seen to be rapidly dropping, and before the operator of the first station could reach the switchboard both alternators were dead and there was a complete shut-down. The distant station was called and they had had the same experience. Switches were pulled and the machines built up and paralleled with no more difficulty that day.

It is well to note that the two machines in the local station naturally had their own exciter which is a different situation than if all three were excited from the same bus.

Everything was examined for loose connections, etc., but this happened three times before the trouble was finally located in the voltage regulator at the distant station.

This apparatus had been connected incorrectly, and as it worked on the exciter feeder there were times when it could open the switch and remain that way. This is what happened and the regulator was cut out and later corrections were made after which no further re-occurrence of the shut-down happened.

Since this worked to kill the exciter on the 500 kw. alternator it would seem that it would be comparable to opening the field switch.

East Cambridge, Mass. GEORGE H. KIMBALL.

FOUR ROTARY BLOWERS with total capacity of 85,600 cu. ft. min. of free air are used in the store of R. H. Macy & Co., New York, to serve 1000 pneumatic tube lines at 1.1 lb. vacuum.

Stresses in Pipe Bends

UNDER the Readers Conference Page of July 15, 1932 issue, page 575, there appears the subject Stresses in Pipe Bends. I appreciate the article on this subject but would like to have the derivation of assumed constants and general formulae made clear.

The coefficient of expansion is assumed as 1.96 in. in 100 ft. It appears to me that a certain steam pressure and atmospheric temperature must have been assumed so as to get a difference in temperature between the former and the latter, neglecting drop in pressure due to length of pipe, thus giving a maximum difference in degrees in temperature. I would like to know just how the assumed value was derived so that a general formula can be made for other material than that specified in the article in question.

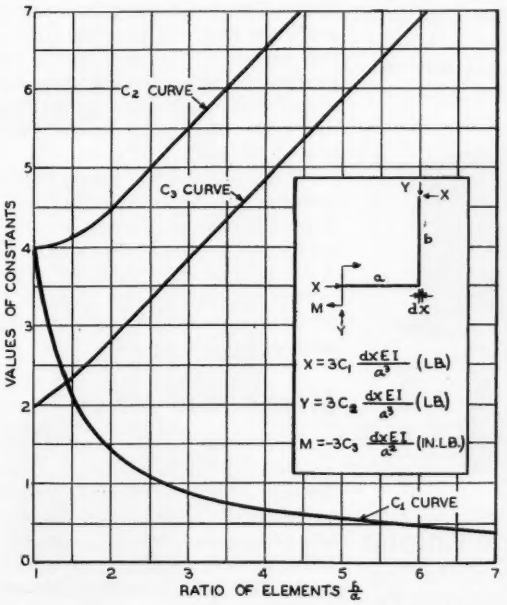


FIG. 1. REACTIONS IN RIGHT ANGLE BENDS.

In regard to Fig. 1, I would like to have the formula for which the assumed constants C_1, C_2, C_3, were plotted including the mathematical derivation of X, Y, and M. This information is for checking the proof and for the making of straight line charts for engineering purposes.

S. L. D.

A. Samuel Kameros of the New York Edison Co., author of the original article, answers as follows:

The first inquiry deals with the question of the coefficient of expansion of steel pipe. The values used by me are those derived by the Messrs. Crocker and McCutchan of the Detroit Edison Co. and incorporated in Fig. 2. This curve is based upon the original Holborn and Day formula with proper constants for the steel used in present day pipe. Points on this curve have been confirmed by experiment and the curve is receiving favorable consideration by the Sectional Committee on the Code for Pressure Piping of the A.S.M.E.

Regarding the second question, your correspondent may easily see that except for a few initial values the equations for the constants C_2 and C_3 are linear and from the shape of the curve the equation for the constant C_1 is probably of the form $C_1 = kr^n$, where r is the ratio $\frac{b}{a}$. However, it is quite unessential to use complicated formulas for this type of bend. W. H. Shipman in Transactions of the A.S.M.E. FSP-51-52 discussed a method of solving pipe bends. In his method certain integrals are designated by the constants A, B, C, F, G, and H. The solution then depends upon the assumption that since both ends are rigidly fixed the following conditions exist: The sum of all horizontal forces is equal to the horizontal component of the reaction; the sum of all vertical forces is equal to the

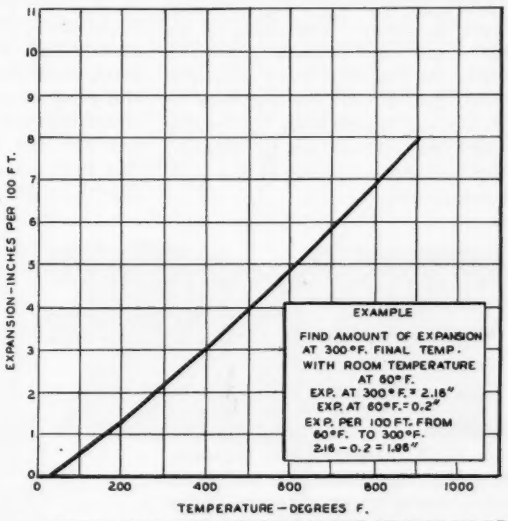

EXPANSION-INCHES PER 100 F.T.
TEMPERATURE-DEGREES F.
EXAMPLE
FIND AMOUNT OF EXPANSION AT 300°F. FINAL TEMP. WITH ROOM TEMPERATURE AT 60°F.
EXP. AT 300°F. = 2.16"
EXP. AT 60°F. = 0.2"
EXP. PER 100 FT. FROM 60°F. TO 300°F.
2.16 - 0.2 = 1.96"

FIG. 2. CURVE FOR EXPANSION CALCULATIONS IN SEAMLESS STEEL PIPE.

vertical component of the reaction; the sum of all the moments about any point is equal to zero.

These three facts may be written as follows, using the constants mentioned above and the nomenclature of Fig. 1.

$$\begin{aligned} GX - BY - FM_o &= x\,EI \\ -BX + CY + AM_o &= y\,EI \\ -FX + AY + HM_o &= 0 \end{aligned}$$

and by the use of determinants the solution is simply:

$$\begin{aligned} X &= [dx\ EI\ (CH - A^2) - dy\ EI\ (AF - BH)] \\ &\quad \div [2\ ABF + CHG - A^2G - B^2H - CF^2] \\ Y &= [dx\ EI\ (BH - AF) - dy\ EI\ (F^2 - HG)] \\ &\quad \div [2\ ABF + CHG - A^2G - B^2H - CF^2] \\ M_o &= [dx\ EI\ (CF - AB) - dy\ EI\ (AG - BF)] \\ &\quad \div [2\ ABF + CHG - A^2G - B^2H - CF^2] \end{aligned}$$

Taking the type of bend discussed in the article, each constant can be derived, assuming varying values of $\frac{b}{a}$.

It will then be found that the solution is simply that of the three equations:

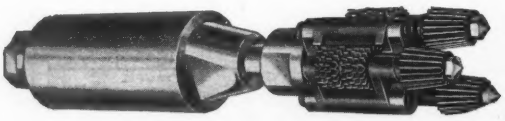
$$\begin{aligned} X &= 3\ C_1\ (dx\ EI \div a^3) \\ Y &= 3\ C_2\ (dx\ EI \div a^3) \\ M_o &= -3\ C_3\ (dx\ EI \div a^2) \end{aligned}$$

The curve (Fig. 1) therefore does away with a great deal of arithmetical work.

New Equipment

Key Airetool

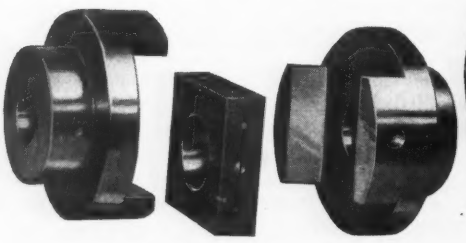
THIS HAS BEEN developed by 20 yr. experience in design to embody sound practical principles of operation. The motor, which is driven by compressed air, is five bladed, of two-stage type, using comparatively low air pressure. The head is so made that by unscrewing the coupling at the rear, arm pins will fall out and the cutters can then be taken out by unscrewing the cutter pin and new cutters put in. Special cutter heads are furnished for special conditions.



For tubes 3¼ in. inside diameter and larger, a muffler can be provided, built integral with the case, decreasing the noise 50 per cent. Lubrication is by an automatic oiler screwed directly into the motor on all tools for straight tubes 2½ in. inside diameter and larger. All sizes are made for straight or bent tubes and pipes, the equipment being a product of the Key Boiler Equipment Co., East St. Louis, Ill.

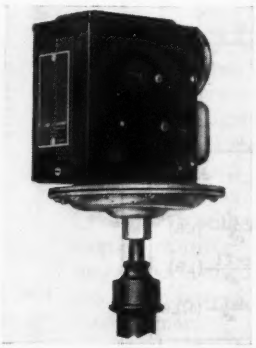
Flexible Coupling

D. O. JAMES flexible coupling is composed of three parts, the center member being made of non-metallic material, self-lubricated by means of a reservoir within itself. This floating center member slides between the jaws of one metal flange on a line passing through the center. It is free to slide across the face of second flange at right angles to the first, making it mechanically flexible without the use of flexible material. The two metal flanges are made of nickel iron.



High Water Alarm

THIS ALARM, manufactured by the Square D Co., is for use over sump or open tanks to sound a warning when the liquid reaches a dangerously high level. It consists of a single-pole pressure switch, a transformer, and signal bell, wired in one unit and mounted on a 1-in. pipe. A rising column of liquid in the pipe exerts air pressure on the diaphragm of the switch, closing a contact and ringing the bell until the high liquid level has been reduced to a safe limit.

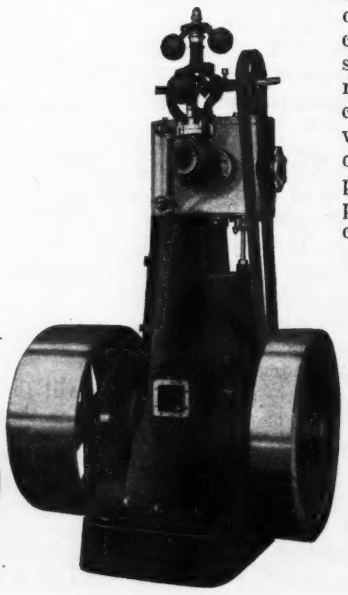


Improved Vertical Engine

IN THIS new design of the Troy Engine and Machine Co., Troy, Pa., a watershed partition has been provided between the cylinder and crankcase. This makes no contact with the piston rod but has drains from piston-rod and valve-stem stuffing boxes to prevent water getting into the oil reservoir and emulsifying with the lubricating oil. It also prevents oil from following up the piston rod to escape into the drain.

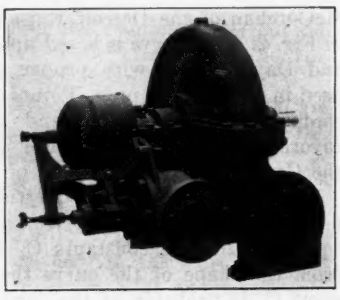
On the 10-in. stroke engines, either flat or piston valves are now available and will soon be provided for all sizes, the flat valve being preferable where steam may carry considerable moisture and the piston type for high-pressure, superheated steam.

Sizes are now furnished in single cylinder of 1 to 225 hp. and in duplex from 2 to 450 hp., vertical or horizontal, enclosed and self-oiling. A 12-in. stroke vertical will soon be introduced of 160 hp. at 300 r.p.m. for continuous 24-hr. service, maximum speed 325 r.p.m.



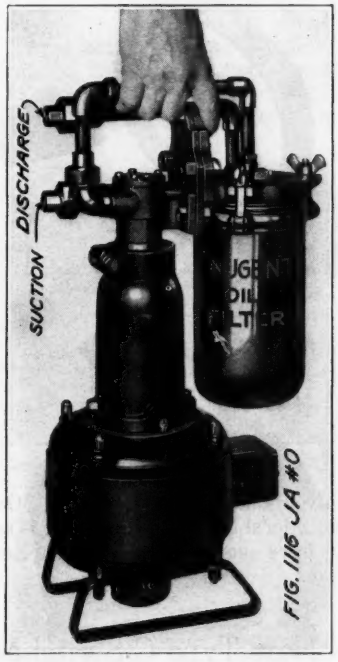
Mechanical-Drive Turbine

NEW mechanical-drive, noncondensing steam turbine for driving centrifugal pumps, fans, and other rotating equipment at speeds from 1200 to 4000 r.p.m. and available up to 250 hp. under suitable steam conditions, has been developed by the General Electric Co. It is a single-stage machine with two rows of revolving buckets. The wheel casing is split horizontally, the steam and exhaust pipes being connected to the lower half of the machine. A centrifugal governor, with weights pivoting on knife edges to operate with little friction, provides proper speed regulation. An independent emergency governor is included.



Portable Oil Filter

WHERE A PERMANENT oil filtering system installation is impractical or too expensive an investment portable oil filter and motor-driven oil pump has many uses. For a unit of this type as illustrated, the suction of the pump may be connected by flexible metal hose or regular piping to the dirty oil drain in the dirty oil reservoir of oil to be filtered, the discharge likewise connected to the inlet of the reservoir. The filtering process starts by plugging the motor wire to any electric light socket and turning on the current. This filtering process does not



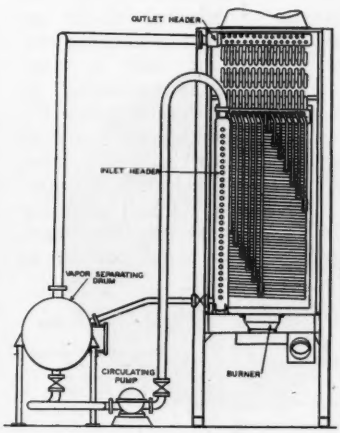
interfere with the continuous operation of the machine to which it is connected.

Time required for filtering depends upon the condition of the oil, the quantity and viscosity. In some cases 20 min. is sufficient, in others an hour. Several sizes of filtering units are manufactured by Wm. W. Nugent & Co., Chicago, Ill.

Dowtherm Vapor for Process Heating

FOR USE as a heating medium in process work the Dow Chemical Co., Midland, Mich., uses Dowtherm vapor generated in a special boiler constructed by Foster Wheeler Corp. Dowtherm consists of a mixture of the phenolic derivatives diphenyl and diphenyloxide (D.P.O.) and has a low vapor pressure, making it possible to employ this method of heating at the high temperature levels of 500 to 700 deg. F. with pressures of from zero to 100 lb. gage. Dowtherm made by the Dow Chemical Co. is non-poisonous and has many advantages in an indirect heating system.

The boiler was designed for a normal heat input of 4,000,000 B.t.u. per hr., or approximately 120 b.hp. A centrifugal pump circulates the Dowtherm through the heating surfaces. The square furnace, lined on all four sides with radiant heat absorbing surface, is fired by a single vertical Peabody wide range oil burner with forced draft supplied by a motor driven propeller fan. The Dowtherm pump driven



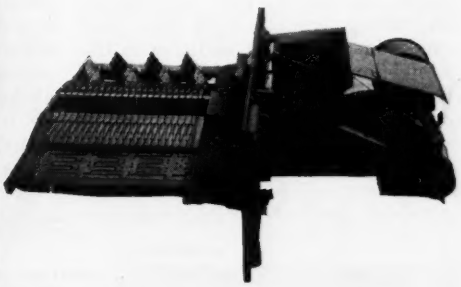
FRONT ELEVATION OF BOILER WITH CASING AND INSULATION REMOVED

by a 30 hp. motor has a capacity of 600 g.p.m. and is electrically interlocked with the oil burner gear pump so that the burner cannot be lighted without starting the circulating pump.

Averages of several tests show the following: Net heat delivered, 4,432,000 B.t.u. per hr.; quantity circulated, 500 g.p.m.; temperature liquid entering boiler, 642 deg. F.; vapor-liquid mixture leaving boiler, 661 deg. F.; vapor in separating drum, 646 deg. F.; stack temperature, 773 deg. F.; vapor drum pressure, 50.3 lb.; circulating pump discharge pressure, 72 lb.

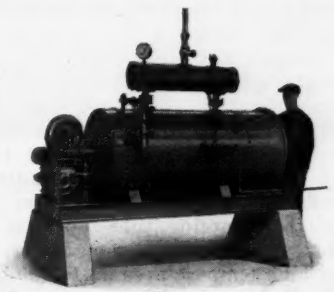
New Small Stoker

FOR BOILERS of 40 to 150 hp. the new Type E unit is brought out by Combustion Engineering Corpn. of New York City. It has a large hopper, designed to prevent arching of coal, which supplies the plunger-ram-type feeding mechanism, with auxiliary pushers all mounted on a plate sliding in the bottom of the retort to give uniform feeding and distribution of fuel. Active grate surface of alternate fixed bars and moving tuyeres gives agitation of the fuel bed. Dead plates at the sides or, for slight added cost, shaking dump grates are provided. Drive is by a dust-proof, constant-speed motor, which also drives an integral fan and has a timing device to regulate number of strokes of the ram over a range of eight to one to control rate of fuel feed, air supply being automatically controlled to correspond. Three sizes are offered: Class 3 with 9 to 17½ sq. ft. projected area, capacity 55 to 120 developed boiler horsepower; Class 4, 12 to 22½ sq. ft. for 75 to 160 hp.; Class 5, 15 to 27½ sq. ft. for 95 to 200 hp.



Self-Contained Boiler

OILBUILT is the trade name of a high-pressure boiler particularly designed for industrial operations requiring process steam. The boiler is of internal combustion, four-pass, down-draft construction with an oil burner built into and especially designed for this particular boiler. The temperature of the flue gas is from 300 to 400 deg. F. No expen-



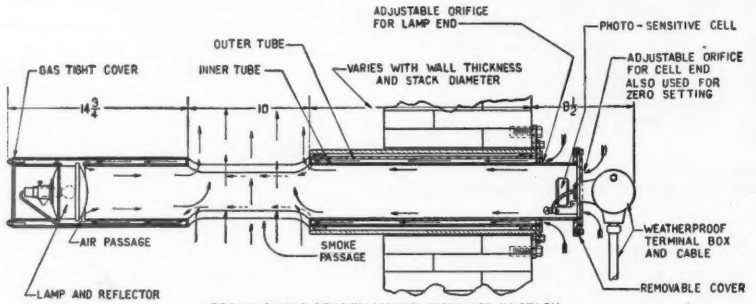
sive foundation or stack is necessary. These boilers may be equipped with completely automatic controls if desired. They are made in sizes from 15 to 125 b.hp. by the Cleaver-Brooks Co., 740 N. Plankinton Ave., Milwaukee, Wis.

The Brown Smoke Density Meter

By R. D. Bean

Brown Instrument Co. has developed a meter for measuring the density of smoke in flue gases by electro-optical means, in which a portion of the flue gas is made to pass between a source of light and a light-sensitive device. With varying smoke density, the amount of light falling upon the light-sensitive device also varies and the resulting current variation from the photo-cell is transmitted to the indicating or recording meter, calibrated in terms of smoke density, as per cent or in terms of Ringelmann smoke scales.

Arrangement as shown includes a recording meter with signal lamps, which can become a practical guide in the improvement of firing technique, as well as give warning of impending trouble with the local smoke inspector. In addition to the signal lamps, or in place of them, the instrument can be arranged to operate a bell, or other alarm device, whenever the smoke reaches the limit permitted by local regulations.



BROWN SMOKE DENSITY METER INSTALLED IN STACK

Equipment includes the sampling tube containing a source of light and a photo-cell the control panel and an indicating or recording instrument.

Sampling tube construction prevents the accumulation of soot or smoke on the contained lamp and light-sensitive device. The light source, a small electric light bulb at the focal point of a parabolic reflector, is placed at the inner end of the sampling tube, operates on 6 v. and is especially made for use in high temperatures up to 600 deg. F. Reflector and lamp are enclosed to protect the surface of the reflector and the electrical contacts on the lamp bulb from corrosion. The light-sensitive device, at the outer end of the sampling tube, is a photo-cell whose current is sufficient to operate standard models of Brown indicators or recorders, either potentiometer or millivoltmeter type. With negligible temperature coefficient, the accuracy of the meter reading is unaffected by variations in the flue gas temperature.

For the sampling tube, two concentric cylinders are welded together at the orifices through which the gas passes so that the annular space between the cylinders forms an air duct leading to the air outside the stack. From the outer end of the sampling tube a four-wire cable is run to the control panel.

Liquid Insulator

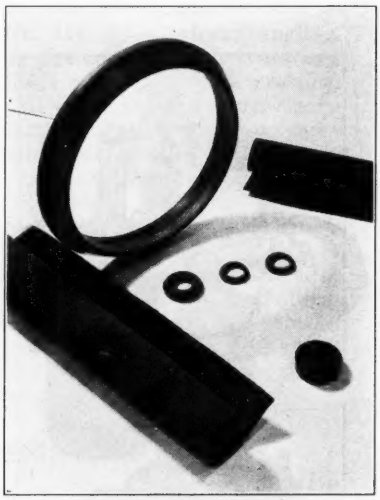
Pyranol, a new synthetic insulator announced by the General Electric Co. is stated to have characteristics as follows: It has the advantages of mineral oil as an insulating and cooling medium for electric equipment and is non-inflammable and non-explosive. It is produced in different forms for different purposes, with varying physical and electrical properties, all having a high dielectric constant.

While mineral oil will probably remain in general use for years, Pyranol permits capacitors to be made smaller per microfarad and, the higher cost of transformers with Pyranol when the equipment must be completely proof against fire and explosion hazards, may be justified. Since the liquid is a solvent for some materials ordinarily used in electric equipment, particularly transformers, the apparatus must be designed specially for its use.

Chemically stable, it resists oxidation, so that there is no sludging after continued exposure to heat or air. It demulsifies, or separates from water, more than twice as rapidly as does mineral oil and the moisture rises to the surface, from which it may be evaporated. Viscosity and freezing point can be varied to suit conditions without affecting other qualities of the liquid. When Pyranol is subjected to an electric arc, the principal product is hydrogen chloride, an irritating but not actively poisonous gas which can be removed by an absorption device or piped to the open air for dissipation.

New Packing

Development of a new packing, item made of Thiokol compounds, such as diaphragms, discs and gaskets, is announced by Garlock Packing Co. The material, a new chemical product, has many characteristics of rubber but is not affected by



solvents nor does it oxidize. Over considerable periods of use, it is said to have shown no sign of deterioration.

New Type C Switches

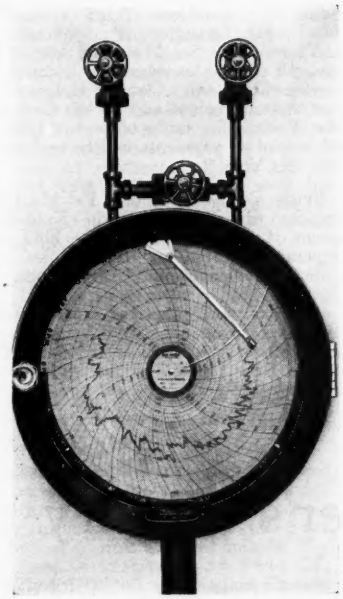
Square D Co., Detroit, Michigan, recently announced this improved line with larger boxes, positive quick-make and quick-break operating mechanism and positive pressure fuse clips, the same as for Type A line, with the exception of keyed interlocking. Capacities range from 30 to 600 amp. at 250 v. and 30 to 200 amp. at 575 v., fused or unfused.

To permit splicing on the job of endless rubber belting, B. F. Goodrich Co. has developed a Highflex Junior belt in widths up to 6 in., a special cement, a Heintz Co. electric vulcanizer and a template for laying out the stepped-down ends of belt for the splice. Necessary hand tools and instructions are included in the outfit.

Mechanical Flow Meter

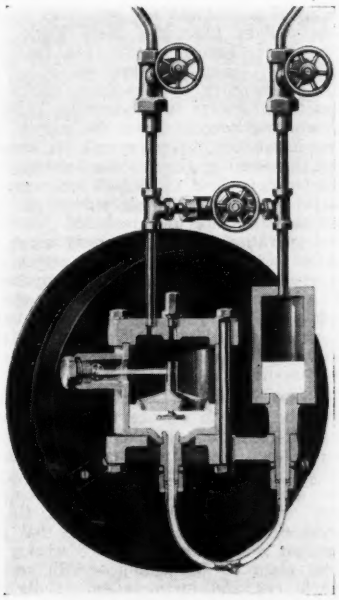
By Thomas R. Harrison*

This New Line of meters has simple, direct lever-actuating mechanism, a large powerful float, a pressure tight bearing with grease reservoir, a series of range tubes that permits changing the range of the meter without disturbing the orifice and construction such that the manometer may be taken apart and cleaned in the field without altering the calibration. The instrument mechanism is built into a die-cast aluminum case, attached to the manometer assembly by means of a three-armed bracket that also supports the high-pressure chamber, a drawn steel cup, and the low-pressure chamber or range tube of seamless steel tubing. The two chambers are connected by means of a steel U-tube, with a drain plug at its lowest point.



Welded to the side of the high-pressure chamber is a forged steel tee-fitting for mounting the pressure-tight bearing in a position for attaching the float lever on one end and the pen linkage on the other end.

This instrument can be furnished to record on either square root chart or evenly divided chart. For a square root chart, linkage motion is transmitted through a pair of cams, designed to roll in contact with each other without sliding friction, to give the pen movement proportional to the square root of the float movement. Without the cams the record of pressure differential across the orifice will be on an evenly divided chart and of flow on a square root chart; with the cams flow will be recorded directly on a chart, evenly divided from 100 per cent down to 10 per cent of full scale; the square root chart is from 10 to 0 per cent. Both theoretical and actual zero lines appear on the chart. All recorder models use 12 in. charts, whether evenly divided or of the square root type.



The pressure tight bearing through which the float motion is carried to the pen linkage has a generous reservoir for grease which acts as a lubricant and a sealing medium, also a pivot ground on the outer end of the shaft bears against a hardened flat plate to take up the thrust. Full scale rotary motion of the shaft is about 22 deg. If the float goes beyond full scale, it seals the high-pressure chamber against mercury blow-out by means of a special seat in the high-pressure chamber and a disc carried on the bottom of the float, this seal opening again when the rate of flow falls within the range of the instrument.

Multipen models may have automatic compensation for variations in pressure or temperature or both of the fluid being measured, by varying a sensitivity lever between the manometer float and the flow meter pen.

All recording models have either hand-wound or electric chart drive, for a variety of chart speeds. An integrator arm contacts a sector carried on the pen shaft every 6 sec. and a clutch engages the driving motor to operate the totalizer, whose reading is recorded on a set of vernier graduations at the edge of the chart, so that a record of both the rate of flow and the total flow is made on the chart.

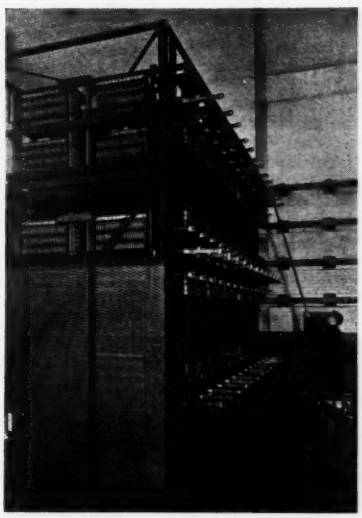
Control models in both the single and duplex forms have been developed, to operate mercury switches and handle 15 amp. at 110 v. directly through the instrument without the use of relays, the switches being tilted in a direction depending upon whether the pen is above or below the set value on the chart. On two-pen instruments, this will automatically control flow and either temperature or pressure, by operating motorized valves and pumps, also will operate alarm devices and signal lights.

Any model may be mounted on a floor stand, wall bracket or pipe saddle, or flush mounted on a panel with other instruments in a flush-mounted installation.

*Director of Research, Brown Instrument Co., Philadelphia, Pa.

"Pure" Resistance for Test Work

These seventy-two special nickel-alloy resistor units are an important part of Westinghouse's new



60,000 Kv-a. testing laboratory—one of the world's largest.

By proper manipulation of series-parallel switches the resistance of the bank can be made anything from 6.25 ohms to 0.0433 ohms. The maximum current rating is nearly 100,000 amperes for five seconds. Unlike ordinary cast iron grids, nickel-alloy grids are practically non-magnetic and hence give "pure" resistance which prevents distortion of the testing voltage.

News From the Field

ELLIOTT Co., Pittsburgh, Pa., and associates The Lagonda Mfg. Co., and Liberty Mfg. Co. announce the removal of their Baltimore District Office to Washington, D. C. The new address is 918 Washington Loan and Trust Building, 9th and F Sts., N. W. H. C. Hale is district manager. C. H. Russell remains in Baltimore at 3602 Calloway Avenue, as resident sales engineer.

STONE & WEBSTER Engineering Corp. has been authorized by the Potomac Electric Power Co. to place a contract with the General Electric Co. for a 35,000-kw. turbine generator unit to be installed in the $5,000,000 power station to be constructed at Buzzard Point, in Washington, D. C. The turbine will operate at 650 lb. and 825 deg. F., delivery scheduled for June 1, 1933.

HENRY VOGT MACHINE Co., Louisville, Kentucky, announces the appointment of J. R. Fortune & Son, 608 Fisher Building, Detroit, Michigan, as its district representative for steam boilers, Homeweld pressure vessels and heat exchange equipment.

E. R. JEFFERSON, for some years a partner in Striegel & Jefferson, Inc., New York, has severed his connection with that firm and, together with Frank A. Lobee, Jr., has formed the Insulation and Refractories Co., located at 841 Elmwood Ave., Buffalo, N. Y. This company represents the Bernitz Furnace Appliance Co., the Carborundum Co. and Eagle-Picher Lead Co. for Upper New York state.

BERNITZ Furnace Appliance Co. announces the appointment of Ernest R. Jefferson, formerly with Striegel & Jefferson, Inc., and Frank A. Lobee, Jr., formerly with McLeod & Henry Co., the two men operating as Insulation and Refractories Co., 841 Elmwood Ave., Buffalo, N. Y., to handle Bernitz products in western New York state. Also, Lloyd R. Leatherman is now district sales manager for the Chicago district with branch office at 360 No. Michigan Ave. and for the Detroit district with office at 2241 Book Bldg.

MCCLAVE-BROOKS Co. announces the appointment of Charles M. Setzer & Co., Charlotte, N. C., as sales representatives for North and South Carolina of its stokers and grates.

JEFFREY Manufacturing Co., Columbus, Ohio, has announced the removal of its Southwestern branch office from Houston to Dallas, Texas. T. P. Burke continues as manager.

AMERICAN Society of Heating and Ventilating Engineers will hold a special meeting Nov. 21 at 5:30 p.m. at 2 Park Av., New York City, to take action on amendment of the By-Laws as to initiation fees and dues. This will be followed by a dinner meeting of the New York Chapter with discussion on Ventilation Standards.

President F. B. Rowley of Minneapolis has been visiting chapters in the west, Seattle, San Francisco, Los Angeles and Kansas City, speaking on Ventilation for Comfort and Health.

Annual meeting of the Society will be Jan. 23-25 at Hotel Gibson, Cincinnati, Ohio. Papers will be presented on Measurement of Wall Surface Temperatures, Air Infiltration Through Steel-Framed Windows, Corrosion in Air-Conditioning Equipment, Refrigeration Applied to Air Conditioning, Residence Cooling, Oil Burners, Radiation from Hot Water Piping, Smoke Abatement, Effect of Cold Walls on Comfort, Capacities of Risers and Mains for Water, Air and Condensate. Entertainment and a ladies' program will be provided.

ALLIS-CHALMERS MFG. Co. has just been awarded a contract for over half a million dollars from the New York City Board of Transportation for the new Eighth Avenue subway system. This covers mercury arc rectifier equipment and transformers for converting 13,500-v. alternating current from the supply system into 625-v. direct current for feeding the third-rail system of the subway line. The high-tension oil circuit breakers, the direct-current switching equipment and switchboards are also included. Starting and operation of the equipment is entirely automatic, made possible by supervisory control circuits and automatic apparatus. The contract is to be completed and in operation within 10 mo. and will furnish power for the Houston Street line of the $600,000,000 independent city-owned subway system.

NEW KEYSTONE LUBRICATING Co. plant is to be built to replace the one recently burned in Philadelphia. Contract was signed two days after the fire and operations started at once, the plant getting into operation while administration quarters are being finished. H. A. Buzby, president of the company states that production is expected in 6 to 8 weeks, the new plant to be equipped with newest machinery and methods embodying improvements suggested by 48 yr. experience. Meantime orders will be filled from ample stocks in supply houses, orders being taken at the temporary offices in Steel Heddle Co. Bldg., 21st and Allegheny Ave., Philadelphia.

TO HANDLE increasing business in the central states, Burns & McDonnell Eng'g. Co. has opened a Cincinnati office at 612 Dixie Terminal Bldg. in general charge of C. F. Lambert, with H. J. Rosson as office manager, to handle consulting and design work on municipal engineering including electric light and water supply plants, sewer systems, appraisals and rate reports.

BABCOCK & WILCOX Co. has been awarded a contract by the Potomac Electric Power Co., Potomac Power Station, Washington, D. C., for two complete boiler units, each having a capacity of 375,000 lb. of steam per hour. The units consist of B & W boilers, superheaters, economizers, air heaters, and desuperheaters, with Bailey water-cooled slag-tap furnaces.

OCT. 1 the Marlin-Rockwell Corp. consolidated the sales activities of its 3 subsidiaries, Gurney Ball Bearing Division, Standard Steel & Bearings, Inc., and Strom Bearings Co. Offices will be maintained for products of all three divisions at Woodford Ave., Plainville, Conn., 402 Chandler St., Jamestown, N. Y. and 2526 So. Michigan Ave., Chicago, Ill. Also branches are located in Detroit, Cincinnati, Cleveland, Los Angeles, San Francisco and 40 W. 63rd St., New York. The main office for billings and receipt of payments will be in Jamestown, N. Y.

FRICK Co., Waynesboro, Pa. has been appointed distributor for the Kold-Kan system of refrigeration used to hold low temperatures in motor truck bodies and in display cabinets for frozen foods.

AFTER 3 yr. engineering work on the New York force, D. M. Archer has been appointed representative of the Sarco Co. for the New England states, with offices at 11 Wolf Street, W. Roxbury, Boston, Mass.

For the Engineer's Library

A NEW 8 PAGE BULLETIN No. 38 has just been issued by Baldwin-Southwark Corporation covering I P Morris Propeller Turbines having adjustable blades and fixed gates. These turbines are intended primarily for low heads and are designed to supply an efficient unit at a price lower than the price of the adjustable gate-adjustable blade propeller turbines with their two complete sets of control equipment. They are particularly indicated where the revamping of existing and less efficient plants is in contemplation.

The Bulletin includes power-efficiency curves, line drawings of the turbines and a "Chart of Characteristics for Standard Turbines" in two colors.

DETROIT LO STOKERS for underfeed of fuel to rectangular firebox heating boilers are described in a 16-p. catalog of the Detroit Stoker Co., General Motors Bldg., Detroit, Mich. It gives applications to various types of boilers, tables of sizes and capacities, efficiency table and other data.

FROM THE Isometer Co., 2357 No. 29th St., Milwaukee, Wis., is received a bulletin describing the Isometer for measurement of flow of liquids, with explanation of its principle of action, illustration of details of construction and of the method of recording.

BLACKMER Rotary Pump Co., Grand Rapids, Mich., in a new leaflet, describes and illustrates its new hand-driven rotary pumps for dispensing oils from storage tanks or barrels. Lift is 20 ft. and maximum capacity 10 g.p.m.

AMERICAN Marsh, motor-driven, single-stage centrifugal pumps, carried on the motor base with pump overhanging are described and illustrated in bulletin 100A of the American Steam Pump Co., Battle Creek, Mich. Sizes are from 1½ in. suction and 1 in. discharge to 3½ in. suction with 3 in. discharge. Suction may be from the outside end, or from the inside with four positions of suction possible. Tables of performance of various sizes are given at heads of 5 to 120 ft.

CURING CONCRETE WITH SILICATE OF SODA is the title of a 62 page, 9x12, fabricoid booklet published by the Sodium Silicate Manufacturers Institute, J. P. Elkinton, Secy., 121 S. 3d St., Philadelphia, Pa. Price, $1.50, prepaid. This well illustrated booklet is a handbook of concrete curing and although intended primarily for the highway engineer, the information contained in it is applicable to all kinds of concrete work and in addition to tables, charts and data on concrete and cement in general, contains standard A.S.T.M. specifications applicable to concrete construction work. A limited number of free copies are available for highway engineers.

ADSCO water heaters as made by American District Steam Co., No. Tonawanda, N. Y. are described and illustrated in its Leaflet No. 432. The heating unit is of copper U tubes with ends expanded into a header.

PRESTO-O-LITE TORCHES, illustrated, published by The Linde Air Products Co., New York, contains descriptions of its complete range of equipment for soldering, brazing and heating requirements, with range of applications and types of work for which that equipment is suited.

COCHRANE DISCHARGER, a pilot-operated steam trap, made by the Cochrane Corp., Philadelphia, Pa., is described in its bulletin No. 694. Illustrations show two solid bodies, mounted on opposite ends of a beam which oscillates to operate a pilot valve admitting steam to force down the plunger of the main valve against spring pressure. Thus any pressure may be used to open an unbalanced valve to any desired rate of discharge. Bodies are of semi-steel, cast steel or forged steel for pressures up to 1850 lb. and for discharge up to 280,000 lb. an hr. under differential pressure of 600 lb. per sq. in.

TYPE E Stoker unit for boilers from 40 to 150 hp. as recently placed on the market is described and illustrated in a bulletin issued by Combustion Engineering Corp., 200 Madison Ave., New York City.

RILEY MODEL R underfeed stokers are described in a new catalog issued by Riley Stoker Co., Worcester, Mass.

WARREN STOCK pumps, for pulp and paper mills but adaptable for other liquids which carry solids in suspension, such as sewage and process, industries wastes, are described and illustrated in bulletin No. 202-2 issued by Warren Steam Pump Co., Inc., Warren, Mass. Charts for friction loss in various sizes of pipe also for relation of stock tonnage capacity to gallons per minute are included.

ROCK DRILLS and Sharpeners is the title of a 32-page illustrated catalogue containing information concerning Ingersoll-Rand equipment for drilling rock and for reconditioning drill steels. Copies of the catalogue, Form 4101, may be obtained from the general offices of Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

NO SCALE, NO SLUDGE, NO MUD—The application of Zeolite Water Softeners to the treatment of Boiler Feed Water is the title of a 36-page booklet published by The Permutit Co., 440 Fourth Ave., New York. It is fully illustrated with photographs and diagrams, contains tabulated data, conversion tables, factors, reactions; also explains the formation of scale, its effects on heat transfer and the principle of action and equipment for Zeolite treatment. Copies may be obtained by request to the above company.

BROWN MECHANICAL flow meter is announced, described and details illustrated in a folder issued by The Brown Instrument Co., 4491 Wayne Ave., Philadelphia, Pa.

WESTINGHOUSE Electric & Mfg. Co., E. Pittsburgh, Pa., is sending out a leaflet describing its new FlexArc a.c. welder for 220-440 v., 50-60 cycles, single phase with current range of 4 to 125 amp.

CAST-REFRACT is the trade name given by Quigley Co., Inc., 56 W. 45th St., New York City, to its new line of plastic refractory. Its characteristics and methods of application are described in a 4-page bulletin recently issued.

ELECTRIC EQUIPMENT for mine hoists is described in an interesting 22-page catalog issued by General Electric Co., Schenectady, N. Y. Illustrations and description of details are given and installations shown.

PRESSURE RELIEF and back pressure compensating valves made by Schutte & Koerting Co., Philadelphia, Pa. are described in its bulletin 8-E, supplement 1.

BULLETIN D-45 of the Lawrence Pump & Engine Co., Lawrence, Mass., gives details of the electro-pump for general pumping service, a unit having pump carried on the end of a motor frame for 5 to 200 g.p.m. at total heads up to 90 ft., rated on 15-ft. suction lift.

FOSTER WHEELER Corporation's new bulletin No. WJ-32-6, entitled Vacuum Refrigeration Systems, contains new developments in the design and application of vacuum refrigeration systems and describes recent applications of the principles of vacuum refrigeration, which is especially applicable to the higher temperature ranges of refrigeration. This system can be installed wherever steam is available for operating the thermo compressors and steam jet air pumps, water or brine being directly cooled to temperatures as low as 32 deg. F. Copies of this bulletin may be secured from Foster Wheeler Corp., 165 Broadway, New York, N. Y.

AIR PUFF soot blower systems for fire- and water-tube boilers are described in a bulletin issued by Diamond Power Specialty Corp., Detroit, Mich. Details, consisting of motor-driven air compressor, storage tank, pressure-actuated controls, pilot valve, blower arm rotated by piston rack and gear are shown for the fire-tube system and corresponding controls for the water-tube. Push-button starting brings in the compressor. Automatically, when air reaches 120 lb., the blowing operation is carried out until pressure drops to 80 lb. or the operation is completed. If pressure drops below 80 lbs., blowing is suspended until 120 lb. is again attained, when blowing is resumed. On completion of blowing one boiler, operation is transferred to a second and so on until all have been blown.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published monthly at Chicago, Illinois, for October 1, 1932.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary Public in and for State and county aforesaid, personally appeared Arthur L. Rice, who, having been duly sworn according to law, deposes and says that he is the Editor of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, R. E. Turner, Chicago, Ill.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.
Chas. S. Clarke, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
R. E. Turner, Chicago, Ill.
A. W. Kramer, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

TECHNICAL PUBLISHING CO.
ARTHUR L. RICE, Editor.

Sworn to and subscribed before me this 22nd day of September, 1932.

[Seal.] EDDIE H. KAHL,
Notary Public.

(My commission expires March 21, 1936.)

Power Plant Construction News

Ala., Atmore—Riebach-Mandell Co., 1410 Broadway, New York, N. Y., plans installation of motors and other electric power equipment in proposed new silk mill at Atmore, where property has been acquired. Entire project is estimated to cost close to $90,000.

Ark., Bearden—Common Council plans installation of pumping machinery and auxiliary equipment in connection with proposed municipal waterworks and sewage system, entire project reported to cost over $300,000. F. J. Batchelor is mayor, in charge.

Calif., Oakland—Standard Brands, Inc., 245 Eleventh Street, San Francisco, Calif., affiliated with company of same name at 595 Madison Avenue, New York, plans installation of electric power equipment in proposed new multi-story yeast-manufacturing plant at San Leandro Boulevard and Jones Avenue, Oakland, where site has recently been purchased. Cost over $500,000.

Calif., San Francisco—Bureau of Yards and Docks, Navy Department, Washington, D. C., plans extensions and improvements in power plant at Mare Island Navy Yard, estimated to cost $325,000, with equipment. Plans will be drawn and bids asked at early date. Appropriation approved.

Colo., Fort Collins—Citizens have approved bond issue of $745,000 at special election, fund to be used for a proposed municipal electric light and power plant. Plans are being completed by Burgis C. Coy, Fort Collins, consulting engineer.

Ill., Elmhurst—City Council is considering installation of new water softening plant for municipal water system. Cost estimated close to $100,000, with equipment. Preliminary report on project has been made by Consoer, Older & Quinlan, 205 West Wacker Drive, Chicago, Ill., consulting engineers.

Ind., Peru—Board of Public Works is having plans prepared for extensions and betterments in municipal electric light and power plant, with installation of new turbo-generator unit and accessories. Cost reported over $85,000. Charles Brossman, Chamber of Commerce Building, Indianapolis, Ind., is consulting engineer.

Iowa, Corning—City Council is perfecting plans for construction of a municipal electric light and power plant, estimated to cost $160,000, with equipment. Special election has been arranged to provide bonds in amount noted. Vincent J. Mack, city clerk.

Iowa, Fort Madison—Illinois-Iowa Bridge Co. and Robert W. Curtis, Curtis Power & Light Co., 18 North Fifth Street, both Keokuk, Iowa, have secured permission from Federal Power Commission, Washington, D. C., for a hydro-electric power development on Des Moines River, vicinity of Croton, near Fort Madison, with power dam 730 ft. long and 18½ ft. high, and power station with three 1500 kva. generating units and auxiliary equipment. Project will include a transmission line and is reported to cost over $500,000.

Ky., Raceland—City Council is said to be planning installation of pumping machinery and auxiliary equipment in connection with new municipal waterworks, entire project reported to cost about $40,000.

Md., Salisbury—Eastern Shore Public Service Co., Salisbury, has authorized construction of new transmission line from Salisbury to Crisfield, Md., and number of shorter transmission lines, with extensions in distributing system. Work is estimated to cost about $250,000. Company engineering department will be in charge.

Mich., Alpena—City Council is having plans completed for a municipal electric light and power plant, reported to cost over $60,000, with equipment. Francis Engineering Co., Saginaw, Mich., is consulting engineer.

Mich., Jackson—Board of Public Works, Jackson, is planning construction of a pumping plant in connection with new sewage disposal works, entire project estimated to cost over $600,000, with equipment. Fargo Engineering Co., Jackson, is consulting engineer.

Mich., Wyandotte—Sharples Solvents Corporation, Twenty-third and Westmoreland Streets, Philadelphia, Pa., plans installation of motors and other electric power equipment in new plant for amyl alcohol manufacture at Wyandotte, entire project reported to cost over $75,000.

Minn., Hutchinson—City Council is considering report recently submitted by E. G. Briggs, Bremer Arcade, St. Paul, Minn., engineer, covering construction of a municipal electric light and power plant, estimated to cost $270,000, with equipment. Engineer noted was employed to make survey for project.

Minn., Minneiska—United States Engineer Office, Commerce Building, St. Paul, Minn., is having plans completed and plans early call for bids for new locks and dam No. 5, Mississippi River, vicinity of Minneiska, including power equipment, lock operating machinery and other mechanical equipment. Entire cost close to $1,000,000.

Minn., St. Paul—Minnesota Mining & Mfg. Co., 791 Forest Street, plans installation of electric power equipment in new two-story addition to abrasive paper manufacturing plant, entire project reported to cost approximately $40,000, with equipment. Toltz, King & Day, Inc., Builders' Exchange Building, is architect.

Minn., Thief River Falls—City Council, P. A. Pederson, city clerk, is said to be planning installation of new Diesel engine unit and accessories for municipal electric light and power plant, about 750 hp. capacity.

N. H., Portsmouth—Bureau of Yards and Docks, Navy Department, Washington, D. C., will prepare plans for extensions and improvements in power plant at Portsmouth Navy Yard, including installation of equipment. Appropriation of $250,000 available for work.

N. J., Hackensack—Alderney Dairy Co., 26 Bridge Street, Newark, N. J., plans installation of electric power equipment in proposed new milk plant and distributing station near Hackensack Avenue, Hackensack, entire project to cost over $70,000.

N. Y., Ozone Park (L. I.)—Kops Brothers, 120 East Sixteenth Street, New York, plan installation of motors and other power equipment in new corset manufacturing plant at Ozone Park, entire project estimated to cost over $125,000. Work on superstructure will soon begin.

N. C., Fayetteville—City Council is considering a report recently submitted by Olsen & Johnson, 5 Exchange Place, Raleigh, N. C., engineers, for construction of a municipal electric light and power plant. It is understood that plans will be prepared by engineers noted.

Ohio, Oberlin—City Council has plans under way for a municipal electric light and power plant to cost $250,000, with equipment. Bonds will be voted at November general election. R. Husselman, Hippodrome Building, Cleveland, Ohio, is architect and engineer.

Okla., Oklahoma City—Donleon Oil Co., care of W. U. Paul, 2701 N. W. Twenty-first Street, recently organized by Mr. Paul and associates, with capital of $300,000, plans installation of power equipment, pumping machinery, tanks and other mechanical equipment in proposed new oil refinery, entire project reported to cost close to $100,000.

Pa., Pittsburgh—South Pittsburgh Water Co., 238 Brownsville Road, Pittsburgh, plans installation of pumping machinery and auxiliary equipment in connection with proposed expansion program at Beck's Run water plant, to increase present capacity about 25 per cent. A. B. Lynn is general manager.

Pa., Smith's Ferry—Pittsburgh Coal Co., Oliver Building, Pittsburgh, Pa., plans installation of mechanical loading, conveying and other power equipment at proposed new coal docks and loading station at Smith's Ferry, Little Beaver River, near Beaver, Pa. Entire project will cost over $30,000. Application for permission to build plant has been made.

S. D., Madison—City Council is considering an addition to municipal electric light and power plant to cost about $105,000, with equipment. Reconstruction Finance Corporation, Washington, D. C., has approved loan in that amount to municipality for project. George H. Simpson, Jr., is city clerk.

Texas, Round Rock—Common Council plans installation of pumping machinery and auxiliary equipment in connection with new municipal waterworks. Elevated steel tank and tower also proposed. J. W. Beretta Engineers, Inc., National Bank of Commerce Building, San Antonio, Tex., is engineer.

Va., Luray—Luray Ice Co., Luray, is considering purchase of a Diesel oil engine unit for installation at plant, about 60 hp. capacity, with accessories.

Wash., Seattle—A. G. Ghiglione & Sons, Inc., Sixth Street South, plans installation of electric power equipment in connection with proposed rebuilding of macaroni plant recently destroyed by fire with total loss of about $90,000.

Wis., Rhinelander—City Council is considering construction of a municipal electric light and power plant, and will have surveys and estimates of cost made by Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., engineer.